Appendix D.4
Sediment Trap Results and Analysis

PDI Evaluation Report

Portland Harbor Pre-Remedial Design Investigation and Baseline Sampling

Portland Harbor Superfund Site
Portland, Oregon

AECOM Project Number: 60566335
Geosyntec Project Number: PNG0767A

June 17, 2019

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CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Betsy Ruffle

June 17, 2019

Betsy Ruffle PDI Project Coordinator AECOM Technical Services	Date

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ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
1,2,3,7,8-PeCDD	1,2,3,7,8-pentachlorodibenzo(p)dioxin
2,3,4,7,8-PeCDF	2,3,4,7,8-pentachlorodibenofuran
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
95 UCL	95% upper confidence limit of the mean
AECOM	AECOM Technical Services
cfs	cubic feet per second
cm	centimeter
COC	contaminant of concern
CSM	Conceptual Site Model
CUL	cleanup level
DDx	sum of dichlorodiphenyltrichloroethane and its derivatives
D/U Reach	Downtown Reach and the Upriver Reach
EPA	United States Environmental Protection Agency
FS	Feasibility Study
FSP	Field Sampling Plan
FSR	Field Sampling Report
Geosyntec	Geosyntec Consultants, Inc.
ID	identifier
mg/kg	milligrams per kilogram
PDI	Pre-Remedial Design Investigation
Pre-RD AOC Group	Pre-Remedial Design Agreement and Order on Consent Investigation Group
RAL	Remedial Action Level
RI	Remedial Investigation
RM	river mile
ROD	Record of Decision
Site	Portland Harbor Superfund Site
PAH	polycyclic aromatic hydrocarbon
TOC	total organic carbon
TSS	total suspended solids

1. INTRODUCTION

The Pre-Remedial Design Agreement and Order on Consent Group (Pre-RD AOC Group) for the Portland Harbor Superfund Site (Site) in Portland, Oregon, has developed and implemented a Pre-Remedial Design Investigation (PDI) for the Site. The Site Record of Decision (ROD) (United States Environmental Protection Agency [EPA] 2017) described a post-ROD sampling effort for the Site to delineate and better refine the sediment management area footprints, refine the Conceptual Site Model (CSM), determine baseline conditions, and support remedial design. The PDI studies were conducted by the Pre-RD AOC Group pursuant to a PDI Work Plan (Geosyntec Consultants, Inc. [Geosyntec] 2017) as a foundational step to update current conditions since collection of data during the remedial investigation/feasibility study (RI/FS).

The Site is located on a 10-mile stretch of the lower Willamette River from river mile (RM) 1.9 upstream to RM 11.8. The Site covers approximately 2,200 acres[1] of an active industrial, commercial, and urbanized harbor and is located immediately downstream of the urban downtown. There are two reaches located immediately upstream of the Site. The Downtown Reach, which includes the urbanized area of downtown Portland, is defined by EPA as extending from RM 11.8 to RM 16.6. EPA defines the Upriver Reach as extending from RM 16.6 to RM 28.4. Collectively, RM 11.8 to RM 28.4 is referred to as the Downtown/Upriver Reach (D/U Reach).

1.1 Sediment Trap Sampling Overview

The PDI studies included the collection of sediment trap samples at two transects upstream of the Site during three distinct deployments (low-flow, storm-flow, and high-flow conditions). Transect 06 is located at RM 11.8 at the Site/Downtown Reach boundary, and sediment traps at this transect collect settleable suspended solids/sediment that pass from the Downtown Reach and into the Site (Figure 1). Transect 07 is located at RM 16.2 near the boundary between the Downtown Reach and Upriver Reach, and sediment traps at this transect collects similar material that passes into the Downtown Reach from the Upriver Reach (Figure 2). Herein, these transects are referred to as RM 11.8 transect and RM 16.2 transect for clarity. Two locations, one on the east and one on the west side of the river, were sampled in each transect over each deployment. This appendix of the PDI Evaluation Report presents the results, data evaluation, and conclusions of the sediment trap sampling program. Laboratory reports are presented in Appendix A of this PDI Evaluation Report, along with tabulated data results. Summary statistics are provided in Appendix D.9.

[1] The ROD states the Site is approximately 2,190 acres and extends from RM 1.9 to RM 11.8. However, when mapped in GIS, the 2,190 acres only covers the area from RM 1.9 to 11.6 (at the end of the authorized navigation channel). The acreage from RM 1.9 up to RM 11.8 is more accurately 2,203 acres.

1.2 Objectives of Sediment Trap Sampling Program

The purpose of the PDI sediment trap sampling program was to further characterize waterborne, sediment-bound contamination entering the Site from upstream sources. The sampling program included the measurement of accumulated sediment volumes inside the traps and chemical concentrations of settleable suspended solids. These data provide (i) a better understanding of chemical inputs entering the Site from upstream for ROD contaminants of concern (COCs; see ROD Table 17), (ii) a line of evidence for determining upstream background conditions, and (iii) a line of evidence for natural recovery potential of bedded sediments within the Site.

For this appendix, the 2018/2019 sediment trap data were evaluated in several ways: (i) to assess the concentrations of settleable suspended solids/sediment coming into the Downtown Reach and the Site to inform the characterization of background conditions and recovery potential of bedded sediments;[2] (ii) to compare seasonal differences among different flow regimes (summer low flows, fall/winter storm flows, and late winter/early spring high-flow conditions); (iii) to compare the solids load from the two reaches upstream of the Site; (iv) to evaluate if sediment traps collect a finer fraction of sediments than represented by nearby or upstream bedded sediments; and (iv) to compare the 2018/2019 PDI data to the historical RI data collected in 2006/2007 to monitor changes over time.

2. SUMMARY OF SEDIMENT TRAP SAMPLING

Sediment traps were placed at four upstream stations along two transects at RM 11.8 (Transect 06, ST-T06a/b) and RM 16.2 (Transect 07, ST-T07a/b). These sediment traps were deployed along two of the surface water transects and sampled over similar seasonal conditions as the surface water sampling. Sediment traps were deployed by divers and remained in place for approximately 3 months for each of three consecutive deployments. Timing of sediment trap deployments captured a range of flow conditions. Samples were analyzed for ROD sediment COCs, including metals, semi-volatile organic compounds, polychlorinated biphenyl (PCB) congeners, total petroleum hydrocarbons, dioxins/furans, and pesticides/herbicides, in addition to grain size, total solids, and total organic carbon (TOC). All data are presented in Appendix A, and summary statistics are presented in Appendix D.9; only focused COCs[3] are evaluated here.

Traps were constructed in a clustered array consisting of four glass tubes approximately 15 centimeters (cm) in diameter and 80 cm long in a central mounting frame. The tops of the tubes were deployed at 3 feet above mudline and secured with rebar rods to the sediment bottom with a

[2] This information supports Appendix F-1, Upstream Background Evaluation, which examines this topic in more detail.

[3] Total PCBs, total polycyclic aromatic hydrocarbons (PAHs), sum of dichlorodiphenyltrichloroethane and its derivatives (DDx), 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), 1,2,3,7,8-pentachlorodibenzo(p)dioxin (1,2,3,7,8-PeCDD), and 2,3,4,7,8- pentachlorodibenzofuran (2,3,4,7,8-PeCDF).

grapple anchor line for retrieval (same design and methods used in the RI [EPA 2016]). Sodium azide preservative and saline water[4] were placed in each trap during deployment. Additional details can be found in the Surface Water and Sediment Trap Field Sampling Plan (FSP; AECOM Technical Services [AECOM] and Geosyntec 2018) and the Sediment Trap Field Sampling Report (FSR), provided in Appendix B.4 of this Evaluation Report. Overall, the traps were successfully deployed and retrieved, with adequate sediment volume collected for all analyses.

2.1 Deployment Periods

The PDI study included three sediment trap deployments, each with 75- to 91-day sampling periods:

- Deployment 1: August 17 to October 31, 2018 (low-flow/summer conditions).
- Deployment 2: October 31, 2018, to January 30, 2019 (storm-flow conditions/fall and initial portion of winter high-flow season).
- Deployment 3: January 30, 2019, to April 2019 (high-flow/late winter and early spring conditions).

At the end of each deployment, traps were retrieved, overlying water was decanted, and tubes were placed on ice for transport to the field laboratory for processing. The sediment within each tube was then measured at the field laboratory and described before being transferred into a compositing bowl. The sediment from the glass tubes was composited together into one sample per trap location for chemical analysis. The sample identifiers (IDs) for the RM 11.8 transect are ST-T06a (east bank) and ST-T06b (west bank), and the sample IDs for the RM 16.2 transect are ST-T07a (east bank) and ST-T07b (west bank). Additional details on sample processing are provided in the FSR.

2.2 River Conditions During Deployments

Sediment traps were deployed during targeted seasonal flow regimes as designed. The average daily river flows (based on measurements every 15 minutes) were averaged over each deployment period and were 6,900 cubic feet per second (cfs) during the summer low-flow deployment period, 27,000 cfs for the storm-flow period, and 35,000 cfs for the high-flow period. River flows during the low-flow period were typical for the Willamette River during the summer months, and large storms did not occur until November 2018. A few large storms occurred during the storm-flow deployment, with peak average daily flows between 60,000 and 70,000 cfs (Figure 3). River flows were variable over the storm-flow and high-flow events, with peak average daily flows greater than 60,000 and 80,000 cfs, respectively. Overall, comparison between the 2018/2019 hydrograph and the 2006/2007 hydrograph indicates that average and peak flows were greater during the

[4] Salinity of water inside the trap was measured during retrieval as a quality control step to check that traps had remained upright during deployment. Saline water is denser and expected to remain in the trap while upright.

2006/2007 deployments than during comparable periods during the 2018/2019 deployments (Figures 3 and 4).

2.3 Physicochemical Characteristics of Trapped Sediments

TOC content and grain size distribution of sediment samples are often key determinants of chemical concentrations. This is because smaller particles have a greater surface area-to-mass ratio and therefore more chemical binding surface per unit mass, and TOC binds hydrophobic organic compounds like PCBs and dioxins. Grain size also affects the mobility of particles under various flow regimes. Differences in grain size distribution among the 2018/2019 and earlier datasets (as percent fines) reflect the importance of river flow in sediment transport processes: the higher flows during both the 2018/2019 PDI and RI sediment trap study for 2006/2007 generated samples with lower percent fines, as coarser-grained materials were mobilized by very high flows occurring during the study (Figure 5). The coarser-grained sediments also generally have lower TOC content; however, this was less evident in the 2019 high-flow event, where lower fines but higher TOC concentrations were measured in some samples (Table 2). The concentrations of focused COCs were not strongly correlated with fines content; however, the highest concentrations were generally observed in samples with very high fines content.

The combination of grain size and TOC differences between past and 2018/2019 studies constrains inter-study comparisons of sediment chemistry. Results were OC-normalized to facilitate comparisons across years. Within the 2018/2019 dataset, grain size and TOC are similar, so dry weight COC concentrations can be compared as well as TOC-normalized concentrations.

3. 2018/2019 PDI DATA RESULTS

3.1 Accumulated Sediment Thickness

Accumulated sediment trap thicknesses ranged from 3 to 53 cm in each trap (Table 1, Figure 6). Similar to previous results from the RI (EPA 2016), more sediment accumulated in each trap during the high-flow period (18 to 53 cm) than during the storm-flow period (9 to 30 cm) or the low-flow period (3 to 8 cm). During storm-flow and high-flow conditions, energetic river conditions carry larger amounts of mobilized sediment in the water column.[5] During the low-flow deployment, thicknesses were slightly higher at the RM 11.8 transect compared to the RM 16.2 transect. Conversely, during the storm-flow and high-flow deployments, thicknesses were generally higher at the RM 16.2 transect than at the RM 11.8 transect. Generally, it appears that

[5] The total suspended solids (TSS) results from the surface water sampling events showed contrary results with higher TSS during the low-flow sampling event than during the storm-flow sampling event. However, the surface water sampling events were discrete sampling events representing a single day, whereas the sediment traps were deployed for 3 months. Additional storms during the sediment trap deployment, especially in late December 2018 to early January 2019 (Figure 3), resulted in a higher accumulation of suspended solids in sediment traps.

the Upriver Reach has a higher suspended sediments load, though there is some variability across flow conditions.

Within a given transect, sediment thickness in each of the two trap arrays were similar, indicating similar conditions on each side of the river at the transect locations; the exception to this was RM 11.8 under high-flow conditions, where more sediment accumulated in the RM11.8W sediment trap (53 cm) compared to the RM11.8E sediment trap (18 cm). Traps were placed in water depths of approximately 60 to 65 feet and 35 to 45 feet for the RM 11.8 and RM 16.2 transects, respectively. The center channel water depths were approximately 60 and 90 feet at the RM 11.8 and RM 16.2 transects, respectively.

3.2 Grain Size, TOC, and Chemistry Results for Focused COCs

Chemistry results are presented below for the six focused COCs identified in the ROD (EPA 2017) (Table 2; Figure 7 series). Percent fines (sum of silt and clay size fractions passing the #200 sieve, or <75 micrometers) were >80% in all PDI sediment trap samples under low-flow and storm-flow conditions, with courser material (<50% fines) under high-flow conditions (Figure 7g). The average grain size concentration among all samples and deployments was 73% fines. The minimum TOC value in the sediment traps was 23,000 milligrams per kilogram (mg/kg) (2.3%), which is greater than the Site-wide surface sediment average of 1.8% TOC.

PCBs. Sediment trap results for total PCB congeners ranged from 3 to 41 micrograms per kilogram (µg/kg), with average and 95% upper confidence limit of the mean (95 UCL) concentrations of 9.7 µg/kg and 19.1 µg/kg, respectively, among the 12 samples from the low-flow, storm-flow, and high-flow deployments (Table 2). The average concentration of PCBs in sediment traps is slightly higher than the background sediment value used in the ROD as the cleanup level (CUL; 9 µg/kg). Average PCB concentrations in sediment trap samples at the RM 11.8 transect (15 µg/kg) were almost four times higher than the average concentration at the RM 16.2 transect (4.4 µg/kg), reflecting chemical contributions from the Downtown Reach (Figure 7a). The highest concentration of PCBs was 41 µg/kg, detected at RM 11.8W (ST-T06b) during the low-flow period. Concentrations of PCBs in sediment trap samples were consistently higher during the low-flow deployment than during the storm-flow or high-flow deployments, consistent with the PDI surface water sampling results and the historical RI sediment trap results. Results were not strongly correlated with percent fines, although the highest concentrations of total PCBs were observed in samples with relatively high percent fines (greater than 90%) (Figure 8 series).

Total PAHs. Sediment trap results for total PAHs ranged from 43 to 300 µg/kg, with a 95 UCL concentration of 194 µg/kg (Table 2). Concentrations were at least two orders of magnitude below the ROD CUL of 23,000 µg/kg (Table 2). A higher average sample concentration was measured in sediment trap samples from the RM 11.8 transect (175 µg/kg) than from the RM 16.2 transect (120 µg/kg). Concentrations of total PAHs varied across seasons and sides of the river. Contrary to PCBs, PAH results were not consistently higher during one event over another. At the RM 11.8E and 16.2W locations, concentrations were highest during the low-flow deployment, consistent with surface water sampling results. At RM 11.8W and 16.2E, the highest concentrations were measured during the storm-flow deployment (Figure 7b). Results were not strongly correlated with percent fines (Figure 8 series).

DDx. All sediment trap results were below the ROD CUL of 6.1 µg/kg (average and 95 UCL concentrations of 2.9 µg/kg and 3.5 µg/kg, respectively). At these low levels, there appears to be no clear spatial correlation among the results, but results were generally highest for the storm-flow samples (about 2 to 3 times higher than during the low-flow deployment). DDx was the only focused COC where concentrations were consistently higher in storm-flow samples than low-flow and high-flow samples (Figure 7c). Results were not strongly correlated with percent fines (Figure 8 series).

Dioxins/Furans. Dioxin/furan sediment trap results were a mixture of estimated results (J-qualified) and results below detection limits (33%, 42%, and 60% of results were below detection limits for 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF respectively; Table 2 and Figures 7d through 7f). All detected samples, except for one, were above their respective ROD CULs (2,3,7,8-TCDD: 0.0002 µg/kg; 1,2,3,7,8-PeCDD: 0.0002 µg/kg; 2,3,4,7,8-PeCDF: 0.0003 µg/kg). The highest estimated sample concentrations for 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD were also above the ROD Remedial Action Levels (RALs); both of these samples were collected during low flow from the RM 16.2 transect. A potential positive relationship between dioxin/furan concentrations and percent fines exists, as the samples with higher concentrations tend to be associated with higher fines, but a clear correlation is limited by results below detection limits (Figure 8 series).

3.2.1 Uncertainty of Dioxin/Furan Data

The dioxin/furan analytical results for solid media collected for the PDI, including sediment trap samples, contain a substantial number of qualified results. The data qualifiers assigned by the laboratory and/or the project data validator include J-flagged values, indicating an "estimated" result, and JN-flagged values, indicating the analyte is tentatively identified and the result is estimated. JN-flagged values are associated with results reported by the laboratory as "estimated maximum possible concentrations." The frequency and types of laboratory- and data validator-qualified results in each dataset need to be considered carefully in determining data uses (see Appendix A).

Appendix E evaluates the uncertainty associated with qualified data for the three dioxin/furan congeners listed in the ROD as focused COCs (2,3,7,8-TCDD, 1,2,3,7,8-PeCDD and 2,3,6,7,8-PeCDF) and identifies concentration ranges where reported concentrations are estimated and/or uncertain and how that may affect the data uses for specific project analyses. Further, Appendix E proposes a means to address uncertainties for the dioxin/furan data applications and makes the following conclusions regarding data uncertainty:

- The analysis shows that a large number of the qualified results are close to the congener detection limits.

- Additionally, the ROD CULs and RALs are at or close to the detection limits. Accuracy of results close to the detection limits is reduced due to uncertainties associated with the analytical method.
- The qualified sample concentrations within the dataset lead to some fundamental limitations in the use of the PDI dioxin/furan dataset, including decision-making related to remedy design and implementation at the Site.

3.2.2 East/West Sides of the River

Concentration differences between the east (ST-T06a, ST-T07a) and west (ST-T06b, ST-T07b) side of each transect varied by COC and deployment (Figure 6 series). Among the six focused COCs, data from the low-flow deployment did not have a consistent spatial pattern. During storm-flow conditions, concentrations of most focused COCs were higher at the western side of the RM 11.8 transect than the eastern side (total PCBs, total PAHs, DDx, and 2,3,7,8-TCDD). Conversely, during storm-flow conditions at the RM 16.2 transect, concentrations of all focused COCs were higher at the eastern side than at the western side. Under high-flow conditions, concentrations were consistently similar on both sides of the river for DDx but were higher on the western side of the river for PCBs and PAHs. Dioxin/furan results were more variable.

3.3 Comparison to PDI Surface Sediment Samples

The grain size composition in sediment trap data and surface sediment data was compared to nearby surface sediment samples and the D/U Reach surface sediment generally (Figure 9a and 9b). This comparison is an approach to (i) support that sediment traps captured suspended solids from the water column rather than resuspension of nearby sediment, and (ii) determine whether traps capture sediment more representative of the fine-grain sediment fraction mobilized from upstream than the D/U Reach surface sediment data. If grain size or TOC are similar between sediment traps and nearby surface samples, potential resuspension and capturing of surface sediment into traps may be suspected. Additionally, differences in grain size and TOC between sediment trap samples and the D/U Reach surface sediments would indicate that D/U Reach surface sediment samples alone are not representative of sediments that may be deposited within the Site.

Nearby surface sediment samples relevant to this comparison include those collected upstream of the sediment trap, from the same side of the river and, where possible, within approximately a half mile to a mile of a sediment trap. All PDI surface sediment sampling locations are provided in Appendix B.2 of the Evaluation Report. Eight 2018 surface sediment samples were selected for comparison:

- Within one-half mile of trap:
  - B457 and B458 for comparison to ST-T07a (RM 16.2E)
- Within one mile of trap:

- B432, B434, and B435 for comparison to ST-T06a (RM 11.8E)
- B429, B430, and B431 for comparison to ST-T06b (RM 11.8W)
- B460 and B479-Alternative for comparison to ST-T07b (RM 16.2W)

Grain size distributions and TOC were notably different between material collected by the sediment traps and the nearby surface sediment at all sediment trap locations (Figure 9a and Figure 9b). Both the low-flow and storm-flow deployments resulted in >80% fines in sediment trap samples (average of all three flow events was about 73% fines), whereas nearby sediment samples ranged from 17% to 81% fines, and only one sample had >80% fines. The fraction of fine-grained sediment in sediment traps was nearly double that of the nearby surface sediment samples at the RM 11.8 transect; a slightly smaller difference was noted at the RM 16.2 transect. The much finer-grain material captured in the sediment traps supports that predominantly suspended material was collected in the sediment traps, rather than resuspension of nearby sediments.

Even though the D/U Reach surface sediment sampling program targeted areas of greater than 25% fines, the percent fines and TOC in sediment trap samples at both RM 11.8 and RM 16.2 transects were considerably higher than the average percent fines or TOC in the Downtown Reach or Upriver Reaches, respectively (Figure 9a and 9b). These results indicate that sediment trap samples are a relevant media for evaluation of background conditions in the D/U Reach to fully characterize the fine-grain, high organic carbon fraction of suspended sediments that may be deposited within the Site.

4. CONCENTRATION TRENDS IN COMPARISON TO RI DATA

The 2018/2019 PDI sediment trap results were compared to four rounds of sediment trap sampling from the 2006/2007 RI sampling. Sediment trap design, methods, and deployment durations were similar between the two studies (the same contractor, Gravity Marine Services, built the traps and deployed them). A few modifications from the RI sampling were put in place for the 2018/2019 deployments. The contractor reinforced the frame construction to better withstand the debris and river flows encountered during the RI winter deployments (some traps were lost during the 2006/2007 events). Some of the RI traps had insufficient volume for sampling during the low-flow events (Table 1). The four sediment traps collected during the RI were located near RM 11.3 (RI designations ST007 and ST008) and upstream near RM 16.6 (RI designations ST009 and ST010). Other differences in trap construction between the two studies are summarized in the FSP (AECOM and Geosyntec 2018). Traps compared were located in the same reaches of the river, but locations and water depths varied between the two studies as described in Section 4.1.

4.1 Comparison of Physical Settings and Flows

The 2018/2019 PDI results were compared to the 2006/2007 RI results for the focused COCs. The following PDI and RI traps were placed in proximity to each other:

- PDI-ST-T06b at RM 11.8W and LW3-ST008 at RM 11.5W

- PDI-ST-T07a at RM 16.2E and LW3-ST009 at RM 15.7E
- PDI-ST-T07b at RM 16.2W and LW3-ST010 at RM 15.6W

One RI sediment trap (RI ST007) was located near the RM 11E early action area within the Site. Data results from this trap are summarized in the tables but excluded from comparative analyses with the PDI data because of high concentrations. For example, concentrations of PCBs were 800 times higher at this trap location during the RI low-flow deployment compared to the sediment trap at RM11.5W over the same deployment period. As this sediment trap was placed well within the Site (downstream of RM 11.8), it likely does not represent upstream conditions, therefore it was excluded from comparison with other upstream trap samples.

PDI sediment traps were deployed from 74 to 92 days (average deployment of 86 days; Table 1). The RI traps were deployed for 88 to 109 days (average deployment of 94 days), slightly longer than the PDI deployments. Additionally, average river flow rates were consistently higher in each deployment during the RI than during the PDI deployments. Average sediment thicknesses measured in the traps were variable but generally comparable when flow rates are considered (Table 1).

The Figure 10 series plots sediment trap concentrations (all upstream stations, historical RI and PDI samples combined) versus average daily river flow velocities (cfs) measured at the Morrison Street Bridge at RM 12.7.[6] Total PCB results show a slight inverse relationship with river flow; the highest concentrations were observed during the lowest river flows. PAH results also show a slight decreasing trend with increasing river flows (with the exception of the sample collected from RI trap LWG-ST010 during the storm-flow deployment). DDx results are variable but show a slight increasing concentration trend with increasing river flows, with generally higher concentrations observed during storm-flow deployments indicated watershed-scale contributions. Dioxin/furan concentrations generally decrease with increasing flows, a pattern that appears to be present even when disregarding sample results below detection limits.

The 2006/2007 RI samples had less than 80% fines in all but three samples (Table 3). The larger proportion of sand size particles (generally 30 to 70% sand) likely reflects the higher river flow velocities in 2006/2007 (higher velocity flows can carry coarser-grained [sand-sized] particles) and/or the locations of the RI traps closer to shore (more lateral/shoreline contributions during higher river flows) and in shallower water than the 2018/2019 sampling. The presence of coarser sediment may have contributed to lower sediment trap COC concentrations from 2006/2007. Similarly, TOC concentrations were consistently higher in PDI sediment trap samples than in RI samples.

[6] Willamette River at Portland, U.S. Geological Survey gage no. 14211720, OR; https://waterdata.usgs.gov/nwis/uv?site_no=14211720. Daily average flow was calculated based on flow measured in 15-minute intervals averaged for each 24-hour period, then averaged over each deployment period.

4.2 Comparison of PDI 2018/2019 and 2006/2007 RI Data During Seasonal Flows

Comparison of sediment traps over time is presented for general perspective. While sediment trap construction was similar, river flows, water depth, and placement of the traps were different between the PDI and RI data collection. These factors, along with the differences in grain size and TOC may limit the comparative discussion of chemical concentrations. The RI notes that there were no strong spatial or temporal gradients evident in concentrations measured over the course of a year in settleable suspended sediments collected in the sediment traps (EPA 2016, page ES-8). Similarly, concentrations of COCs in PDI sediment trap samples showed high variability, but some temporal trends and spatial trends were evident in the PDI data for some COCs. Figures 11a through 11f present the 2006/2007 RI sediment trap results compared to the 2018/2019 PDI sediment trap results for total PCBs, total PAHs, DDx, and three dioxins/furans, respectively. The top panel of these figures presents results in dry weight; the bottom panel presents TOC-normalized results. Sample results for the PDI and RI sediment trap samples are presented in Tables 2 and 3, respectively. The sediment trap samples placed for the RM11E study (pink symbols) are shown in the Figure 11 series graphs but are not discussed below.

4.2.1 PCB Concentration Changes

- RM 11.8 transect: Total PCB sample results in 2018 were 2 to 3 times higher (ST-T06a: 26 µg/kg; ST-T06b: 41 µg/kg) than results in 2007 (LW3-ST008: 13 µg/kg) during low-flow conditions. Results from RM 11.8 transect during the 2018 PDI low-flow deployment include the two highest PCB concentrations measured in any of the sediment trap sampling events (RI and PDI deployments). The 2006/2007 and 2018/2019 total PCB results during storm-flow conditions were similar spatially and temporally, and all were less than 10 µg/kg, with the exception of the sediment trap sample at RM 11.3E, which was 29 µg/kg and located within the Site (Figure 11a). Under high-flow conditions, concentrations were lower in 2018. Concentrations of PCBs evaluated on an OC-normalized basis showed similar patterns with slightly reduced variability (Figure 11a).
- RM 16.2 transect: Total PCB results in 2018 were generally 20% to 30% lower (ST-T07a: 7.8 µg/kg; ST-T07b: 5.6 µg/kg) than 2007 samples (LW3-ST009: 10.6 µg/kg; LW3-ST010: 7.56 µg/kg) during low-flow conditions. A similar pattern was observed during storm-flow and high-flow conditions. On an OC–normalized basis, the decrease observed in 2018/2019 samples was more evident (Figure 11a).
- Evaluated more broadly across the D/U Reach, concentrations of PCBs in sediment trap samples do not show any consistent temporal trends between the RI and PDI deployments. Concentrations in sediment trap samples are and have historically been generally below the ROD CUL at the RM 16.2 transect (Downtown/Upriver Reach boundary) but above the ROD CUL at the RM 11.8 transect (Downtown Reach/Site boundary) in most samples.

4.2.2 PAH Concentration Changes

- RM 11.8 transect: Total PAH sample results were slightly higher in 2018/2019 to 2006/2007 during low- and storm-flow conditions, with 2018/2019 samples an average of 1.4 times higher than 2006/2007 samples over both deployments (Figure 11b). Under high-flow conditions, concentrations were lower in 2018/2019, but the percent fines were also much lower (42% versus 77% fines), which could account for the lower concentrations observed among the PDI samples. When evaluated on an OC-normalized basis, the 2018/2019 and 2006/2007 are comparable (Figure 11b).
- RM 16.2 transect: Total PAH sample results were more variable between locations and season, particularly for the RI samples. The 2018 low-flow and storm-flow results are within the lower range of the 2006/2007 results, on both a dry weight and OC-normalized basis, with high-flow results lower in 2018/2019 than in 2006/2007 (Figure 11b). The RI sediment trap at LWG-ST010 exhibited the highest total PAH concentrations during storm-flow conditions. At this location, the RI sample collected during storm-flow conditions (1,300 µg/kg; average daily flow of 73,444 cfs) was 3 to 6 times higher than all other results. The average daily flows were also higher than any of the other deployment periods.
- PAHs are expected to be higher during storm-flow conditions and first flush events (within the first 48 hours of a rain event) from residual sheens and greases draining from paved areas (VanMetre et al. 2004, 2009). Additionally, carbon-rich coarse particles associated with urban settings (including material such as asphalt) tend to be associated with PAH transport (Reible et al. 2018). The LWG-ST10 location is approximately 1,000 feet downstream of an outfall, which, along with the higher flow rates in 2006/2007 than 2018, provides a possible rationale for the comparatively high total PAH concentrations observed during storm-flow conditions relative to the PDI storm-flow results.
- Evaluated more broadly across the D/U Reach, no consistent temporal trends are evident, though concentrations appear to be decreasing in the Upriver Reach based on sediment trap samples in the RM 16 area. Concentrations are consistently below ROD CULs.

4.2.3 DDx Concentration Changes

- All but two results among PDI and RI samples were below the ROD CUL of 6.1 µg/kg.
- RM 11.8 transect: DDx sample results in 2018/2019 were lower than results in 2006/2007 during low-flow, storm-flow, and high-flow conditions, with the exception of one storm-flow sample below detection limits in 2006/2007, on both a dry weight and OC-normalized basis. Contrary to the 2018 findings, where higher concentrations of DDx were detected during the storm-flow deployment than the low-flow and high-flow deployments, the 2006/2007 DDx data were lower during the storm-flow sampling (Figure 11c).
- RM 16.2 transect: DDx sample results in 2018 were lower than results in 2007 during low-flow conditions, while results from the other periods were similar (within the range of results observed) to the RI; however, the 2006/2007 range (0.98 to 6.4 µg/kg) was more

variable than the 2018 range of storm-flow and high-flow data (2.7 to 5.1 µg/kg) (Figure 11c). Evaluated on an OC-normalized basis, the variability in the 2006/2007 data set is reduced, and the 2018 samples are generally below the 2006/2007 samples (Figure 11c).

- Evaluated more broadly across the D/U Reach, DDx results appear to show a slight decreasing trend throughout the D/U Reach, which is more evident when evaluated on an OC-normalized basis. The concentrations of DDx were below the ROD CUL in all 2018 samples, but not for all 2006/2007 samples.

4.2.4 Dioxin/Furan Concentration Changes

- Dioxin/furan congeners 2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, and 1,2,3,7,8-PeCDD were not detected in 25 out of 30 sample results (ST008, ST009, ST010) in 2006/2007 RI. The remaining five results were J- and JT-qualified (Table 3). Among the 2018/2019 sediment trap results, 16 out of 36 results were below detection limits, and 15 out of the remaining 20 detected results were qualified with J- or JN-flags (Table 2). Detection limits were lower by nearly an order of magnitude in 2006/2007 than in 2018/2019.
- Due to the low concentrations, the 2006/2007 and 2018/2019 sediment trap sample results for dioxin/furan congeners were qualified and uncertain but can be interpreted to indicate that concentrations in 2018/2019 are generally higher than 2006/2007 RI results during low-flow, storm-flow, and high-flow conditions (Figures 11d through 11f). Evaluated on an OC-normalized basis, higher concentrations are indicated for 2,3,7,8-TCDD but more variable for 2,3,4,7,8-PeCDF, and 1,2,3,7,8-PeCDD. Detected concentrations in all but one 2018/2019 sediment trap sample were above their respective ROD CULs, where detected concentrations in 2006/2007 were generally more variable.

5. Summary and Implications for the CSM

Sediment trap samples are representative of incoming sediment concentrations to the Site at RM 11.8 and to the Downtown Reach at RM 16.2. The accumulated sediment in traps was finer than the nearby surface sediment (surface sediment samples; ~20% to 80% fines), indicating that sediment trap samples are representative of settleable suspended solids rather than nearby surface sediments. Sediment trap samples (mean 73% percent fines) were also finer than the average bedded surface sediment in the D/U Reach (mean of 45% percent fines), indicating that the sediment trap data represent the fine fraction of sediment more similar to sediment deposited within the Site. This is further supported by the RI, which noted that cross-media comparisons of surface sediments, sediment traps, and suspended solids in surface water (RI Table 10.2-14a-b and Figure 10.2-34b) show that the Site-wide concentrations of all media are statistically different from one another; therefore, all media are important to consider in evaluating upriver contributions.

Based on the evaluation of the 2018/2019 PDI sediment trap data and comparison to the 2006/2007 RI sediment trap data, observations for the updated CSM include the following:

Seasonal Trends

- During the low-flow/summer period, higher concentrations in sediment trap samples were observed compared to storm-flow and high-flow conditions for PCBs and dioxin/furans. As discussed below, sediment trap samples during low-flow deployment had a higher fines fraction, and the highest concentrations of PCBs and dioxins/furans are generally observed in samples with the highest proportions of fines (Figure 8 series).
- Higher river flow velocities mobilize coarser fractions of sediment (Figure 5). Sediment trap grain size data consistently supports this (Tables 2 and 3). The high-flow samples have higher proportion of coarser material than the storm-flow and low-flow events.
- Higher DDx and PAH concentrations were measured in some sediment trap samples during the storm-flow deployment than other flow periods. These results suggest that any potential for concentration inputs to the Site coming from upstream is influenced by different mechanisms for PCBs and dioxins than for PAHs and DDx. Storm-flow conditions contribute more suspended sediment load from upland areas and associated storm drain systems within the watershed. As discussed above, carbon-rich coarse particles associated with urban settings (including material such as asphalt), which are typically mobilized during storm or "first flush" events tend to be associated with PAH transport (Reible et al. 2018). High-velocity river flows are often associated with storm events when such particles are more likely to be captured within storm flows from upland Site surroundings than under low-flow, dry conditions. This is consistent with the observation of higher PAH concentrations expected under storm-flow conditions and first flush events in areas of urban development noted in Section 4.2.2 (VanMetre et al. 2004, 2009).

Spatial Trends

The sediment traps bookend the Downtown Reach and collect settleable suspended sediment that is transported from the Upriver Reach to the Downtown Reach (RM 16.2) or from the Downtown Reach into the Site (RM 11.8).

- For PCBs, PAHs, and DDx, 2018/2019 concentrations were higher at the RM 11.8 transect than at the RM 16.2 transect, regardless of spatial or temporal conditions. Concentrations of PCBs were above the ROD CUL in low-flow samples collected from the RM 11.8 transect.
- Concentrations of 2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, and 1,2,3,7,8-PeCDD were above their respective ROD CULs at both the RM 11.8 and RM 16.2 transects, with higher concentrations of 2,3,7,8-TCDD observed further upstream (RM 16.2), particularly during low-flow conditions. Comparisons of dioxin/furan congeners during low-flow conditions are confounded by the presence of multiple sample results below detection limits. These results indicate that sources of PCBs and dioxins/furans from the urban downtown Portland area to the Downtown Reach and into the Site are ongoing at concentrations above ROD CULs.

Chemistry Trends Over Time

- Concentrations of PCBs, PAHs, and dioxins/furans in sediment traps at RM 11.8 do not show any consistent temporal trends when evaluated on a dry weight or OC-normalized basis. While differences between sampling depths, flow rates, and fines complicate these comparisons, the consistent concentrations of these COCs between the 2006/2007 and 2018/2019 samples indicate the presence of ongoing inputs of these chemicals from the urban downtown Portland area that do not appear to be improving over time. Only DDx shows decreased concentrations between the 2006/2007 and 2018/2019 sediment trap samples.
- At RM 16.2, average concentrations of PCBs, PAHs, and DDx have decreased slightly in sediment trap samples between the RI and PDI sampling events when evaluated on an OC-normalized basis, potentially indicating some improvement in the Upriver Reach for these COCs. However, the range of results between 2006/2007 and 2018 samples overlaps due to variability between events. Overall, there appears to be some decrease in contaminant input from the Upriver Reach for these COCs, but storm-event related variability is still evident.
- Due to the low concentrations, the dioxin/furan congeners results from both the RI and PDI are qualified and uncertain. The estimated results can be interpreted to indicate that dioxin/furan results have increased since the RI results, both spatially and seasonally (15 of 24 results were detected; all detected results were J-flagged).

Measured Concentrations are Supported by Other Studies and Lines of Evidence

These conclusions are supported by the results of sediment trap sampling that was performed in 2009-2010 along RM11E on behalf of the City of Portland (GSI 2010).[7] Samples were collected from two rounds of 3-month deployments: a low-flow event in July-late September 2009 and a high-flow event from October to mid-January 2009-2010 (Figure 12). River flows were similar to the PDI sampling events. Chemical results for these seven sediment traps (RM11E-ST001 to ST-007) are presented in Figures 11a through 11f, and Table 4. The results for the three closest sediment traps to RM11.8 are discussed below.

- The average concentration of total PCBs in the three low-flow samples was 22 µg/kg, consistent with other PDI lines of evidence and more than twice the ROD CUL for PCBs (9 µg/kg). Concentrations were notably lower in the two high-flow samples collected in January 2010.

[7] Of the seven sediment traps deployed for the RM11E study between RM11 and RM12.1, two trap locations were located at or upstream of the Downtown Reach/Site boundary (RM11E-ST007 at RM 12.1; RM11E-ST006 at RM 11.9) and RM11E-ST005 was located at RM 11.7. These three trap locations are spatially comparable to the PDI trap locations.

- Similarly, 2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, and 1,2,3,7,8-PeCDD were detected above the ROD CUL in one high-flow and one low-flow sample and were below detection limits in all other samples. The low detection frequency is consistent with many PDI sediment trap samples and detected concentrations were in the general range of the PDI data.
- Total PAHs and DDx were not detected above ROD CULs in this dataset, consistent with results observed in 2018/2019.

In summary, concentrations of focused COCs in sediment trap samples demonstrate ongoing inputs of COCs from upstream areas. The suspended sediment entering the Site at RM 11.8 transect, in particular, should be included as a line of evidence to support the evaluation of background conditions. This is supported because a finer fraction of sediment was captured in the 2018 traps compared to the D/U Reach surface sediment samples, and results reflect chemical inputs from the Downtown Reach. Background concentrations in sediment are discussed in detail in Appendix F.1 of this PDI Evaluation Report.

6. REFERENCES

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TABLES

Table 1. 2018/2019 and 2006/2007 Sediment Trap Field Deployment Data

PDI Sediment Trap Field Data (2018-2019)

River Mile	Transect Location	Event	Deployment Date	Sample Collection Date	Deployment Duration (Days)	Water Depth (ft)	Average Daily River Flow (cfs)	Average Sediment Thickness[a] (cm)	Average Sediment Volume (L)
11.8E	ST-T06a	Low-Flow	8/17/2018	10/31/2018	74	67	6,908	7.9	1.2
		Storm-Flow	10/30/2018	1/30/2019	92	60	27,732	9.3	1.4
		High-Flow	1/30/2019	5/1/2019	91	64	34,577	18	2.5
11.8W	ST-T06b	Low-Flow	8/17/2018	10/31/2018	74	59	6,908	8.1	1.2
		Storm-Flow	10/30/2018	1/30/2019	92	59	27,732	14	2.1
		High-Flow	1/30/2019	5/1/2019	91	59	34,577	53	7.6
16.2E	ST-T07a	Low-Flow	8/17/2018	10/31/2018	75	46	6,908	4.4	0.6
		Storm-Flow	10/31/2018	1/30/2019	91	33	27,732	30	4.6
		High-Flow	1/30/2019	4/30/2019	90	33	34,577	45	6.4
16.2W	ST-T07b	Low-Flow	8/16/2018	10/31/2018	76	42	6,908	3.2	0.5
		Storm-Flow	10/31/2018	1/30/2019	91	35	27,732	21	3.0
		High-Flow	1/29/2019	4/30/2019	91	44	34,577	42	6.0

LWG Sediment Trap Field Data (2006-2007)

River Mile	Transect Loction	Event	Deployment Date	Sample Collection Date	Deployment Duration (Days)	Water Depth (ft)	Average Daily River Flow (cfs)	Average Sediment Thickness (cm)	Sediment Volume (L)
11.3E [b]	ST007	Low-Flow	8/17/2007	11/13/2007	88	27	11,723	7.9	2.8
		Storm-Flow	11/2/2006	1/31/2007	90	27	73,444	37	13
		High-Flow	1/31/2007	4/30/2007	89	28	38,668	10	3.5
		Low-Flow	4/30/2007	8/17/2007	109	27	12,723	7.1	1.2
11.5W	ST008	Low-Flow	8/17/2007	11/13/2007	88	28	11,723	13	4.4
		Storm-Flow	11/1/2006	1/31/2007	91	29	73,444	69	24
		High-Flow	1/31/2007	4/30/2007	89	30	38,668	16	5.7
		Low-Flow	4/30/2007	8/17/2007	109	28	12,723	2.9	[c]
15.7E	ST009	Low-Flow	8/17/2007	11/13/2007	88	19	11,723	1.7	0.58[c]
		Storm-Flow	11/2/2006	2/2/2007	92	20	73,444	6.3	2.3
		High-Flow	2/2/2007	4/30/2007	87	21	38,668	10.7	3.8
		Low-Flow	4/30/2007	8/17/2007	109	20	12,723	4.9	0.9
15.6W	ST010	Low-Flow	8/17/2007	11/13/2007	88	27	11,723	6.0	2.1
		Storm-Flow	11/2/2006	2/2/2007	92	20	73,444	52	19
		High-Flow	2/2/2007	4/30/2007	87	28	38,668	9.7	3.5
		Low-Flow	4/30/2007	8/17/2007	109	26	12,723	1.4	[c]

General Notes:
1. Sediment traps were deployed for approximately 3 months.
2. Average daily river flow source data: USGS Gage 14211720 Willamette River at Portland, OR (https://waterdata.usgs.gov/nwis/uv?site_no=14211720).

Footnotes:
a. Accumulated thickness per cylinder, average of four composites except for the following: three composites at PDI-ST-T07a and PDI-ST-T07b (10/31/2018) and at PDI-ST07b (1/30/2019).
b. Trap located within the Site near an early action area; results may not represent upstream background conditions.
c. Insufficient material to sample. Sediment traps were redeployed to continue sediment collection.

Acronyms:
cfs = cubic feet per second
cm = centimeters
ft = feet
L = liter
LWG = Lower Willamette Group
PDI = Pre-Remedial Design Investigation
USGS = United States Geological Survey

Table 2. PDI Sediment Trap Chemistry Data Summary (2018/2019)

River Mile	Transect Location	Event	Sample Collection Date	Chemical and Units									
				Total PCBs	Total PAHs	DDx	2,3,7,8 TCDD	1,2,3,7,8 PeCDD	2,3,4,7,8 PeCDF	TCDD-TEQ	Percent Fines (#200)	TOC	TOC
				µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	%	mg/kg	%
11.8E	ST-T06a	Low-Flow	10/31/2018	26	270	2.2	0.00063 J	< 0.00061	< 0.00053	0.0039	92	38,000	3.8
		Storm-Flow	1/30/2019	6.2	140	3.6	0.00027 JN	0.00061 J	0.00043 J	0.0034	86	36,000	3.6
		High-flow	5/1/2019	2.6	46	2.4	< 0.00014	0.0002	< 0.00013	0.0013	48	43,000	4.3
11.8W	ST-T06b	Low-Flow	10/31/2018	41	210	2.2	< 0.00045	< 0.00053	0.00092 J	0.003	94	39,000	3.9
		Storm-Flow	1/30/2019	8.9	300	4.6	0.00046 JN	0.00058 JN	0.00035 J	0.0036	86	40,000	4.0
		High-flow	5/1/2019	4.8	88	2.2	< 0.00015	< 0.00014	< 0.00012	0.00098	32	23,000	2.3
16.2E	ST-T07a	Low-Flow	10/31/2018	7.8	140	1.7	< 0.0023	< 0.0032	< 0.0030	0.011	92	38,000	3.8
		Storm-Flow	1/30/2019	4.2	220	5.1	0.00095 JN	0.00056 JN	0.00032 J	0.004	82	50,000	5.0
		High-flow	4/30/2019	2.1	43	2.7	0.0003	0.0004	< 0.00016	0.0016	41	59,000	5.9
16.2W	ST-T07b	Low-Flow	10/31/2018	5.6	190	1.7	0.0011 JN	< 0.00079	< 0.00085	0.0052	88	36,000	3.6
		Storm-Flow	1/30/2019	3.1	69	3.0	0.00026 JN	0.00055 J	0.00025 JN	0.003	90	47,000	4.7
		High-flow	4/30/2019	3.8	60	3.3	0.0006	0.0004	< 0.00015	0.0025	46	59,000	5.9
			Mean	9.7	148	2.9	0.00063	0.00072	0.00060	0.00362	73	42,333	4.2
			95% Upper Confidence Limit of the Mean	19	194	3.5	0.00064	0.00052	0.00043	0.0055	85	47,622	4.8

Notes:

1. Sediment traps were deployed for approximately 3 months. Low flow event (Aug-Oct 2018); storm event (Nov 2018 to Jan 2019).
2. < = not detected above MDL
3. Total PCB congeners
4. J-flagged values are reported as "estimated" and JN-flagged values reported as "estimated, uncertain."

Acronyms:

µg/kg = microgram per kilogram
DDx = sum of dichlorodiphenyltrichloroethane and its derivatives
MDL = method detection limit
mg/kg = milligram per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PCDD/Fs = polychlorinated dibenzo p dioxins and furans
PDI = Pre-Remedial Design Investigation
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxicity equivalence
TOC = total organic carbon

Table 3. Historical LWG Sediment Trap Chemistry Data Summary (2006/2007)

River Mile	Transect Location	Event	Sample Collection Date	Chemical and Units									
				Total PCBs	Total PAHs	DDx	2,3,7,8 TCDD	1,2,3,7,8 PeCDD	2,3,4,7,8 PeCDF	TCDD-TEQ	Percent Fines (#200)	TOC	TOC
				µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	%	mg/kg	%
11.3E [a]	ST007	Low-Flow	8/17/2007	4,830 JT	640 T	24	< 0.0000133	0.000801 J	0.000734 J	4.0E-02	75	26,600	2.7
		Low-Flow	11/13/2007	11,100 JT	450 T	150	< 0.0000161	< 0.000167	0.247 J	8.2E-02	43	20,900	2.1
		Storm-Flow	1/31/2007	28.7 JT	120 JT	7.4	< 0.000062	< 0.000182	< 0.000017	7.0E-04	67	24,000	2.4
		High-Flow	4/30/2007	840 T	160 JT	7.3	< 0.00014	< 0.000107	< 0.000087	4.1E-03	76	26,200	2.6
11.5W	ST008	Low-Flow	11/13/2007	13 JT	190 JT	4.6	< 0.0000225	0.000188 J	0.000193 J	1.0E-03	73	25,800	2.6
		Storm-Flow	1/31/2007	9.53 JT	120 JT	< 2.5 UT	0.000128 J	< 0.000127	< 0.000101	7.4E-04	28	14,100	1.4
		High-Flow	4/30/2007	6.42 JT	170 JT	5.9	< 0.000127	< 0.00009	< 0.000077	5.1E-04	82	31,400	3.1
15.7E	ST009	Low-Flow	8/17/2007	3.14 JT	200 JT	5.9	< 0.0000264	< 0.0000456	< 0.00003	4.4E-04	NA	27,400	2.7
		Low-Flow	11/13/2007	10.6 JT	NA	3	< 0.000174	< 0.00027	< 0.000214	6.2E-04	NA	34,700	3.5
		Storm-Flow	2/2/2007	5.9 JT	100 JT	0.98	< 0.000014	0.000128 J	< 0.000089	5.8E-04	22	11,100	1.1
		High-Flow	4/30/2007	4.07 JT	77 JT	2.8	< 0.000143	< 0.000142	< 0.000145	7.5E-04	71	31,100	3.1
15.6W	ST010	Low-Flow	11/13/2007	7.56 JT	290 JT	2.6	< 0.0000318	< 0.0000342	< 0.0000244	8.6E-05	92	31,800	3.2
		Storm-Flow	2/2/2007	5.46 JT	1300 JT	6.4	< 0.00008	< 0.000085	0.000101 J	3.7E-04	40	18,900	1.9
		High-Flow	4/30/2007	4.82 JT	79 JT	6.3	< 0.000147	< 0.000113	< 0.00011	2.3E-04	81	29,900	3.0

General Notes:

1. Sediment traps were deployed for approximately 3 months.
2. NA = not analyzed
3. Total PCBs, Total PAHs, Total DDx and TCDD-TEQs were summed using ND = 0 in the historical database and are included here as reported.
4. < = not detected above MDL
5. J-flags indicate the results is "estimated"; JT-flags indicate one analyte within the total was J-flagged.

Footnotes:

a. RM 11.3E location within Site and influenced by site conditions/source area.

Acronyms:

µg/kg = microgram per kilogram
DDx = sum of dichlorodiphenyltrichloroethane and its derivatives
LWG = Lower Willamette Group
MDL = method detection limit
mg/kg = milligram per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PCDD/Fs = polychlorinated dibenzo p dioxins and furans
RM = river mile
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxicity equivalence
TOC = total organic carbon

Table 4. Historical RM 11E Sediment Trap Chemistry Data Summary (2009/2010)

Transect Location	River Mile	Sample Collection Date	Chemical and Units									
			Total PCBs	Total PAHs	DDx	2,3,7,8 TCDD	1,2,3,7,8 PeCDD	2,3,4,7,8 PeCDF	TCDD-TEQ	Percent Fines (#200)	TOC	TOC
			µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	%	mg/kg	%
RM11E-ST001	11.0E	9/21/2009	119	709	1.56	< 0.0000175	0.000346	0.000308	0.0031	81.4	27,800	2.8
		1/13/2010	53.5	1220	14.6	< 0.0000749	< 0.000097	< 0.0000887	0.00061	82.9	40,600	4.1
RM11E-ST002	11.2E	9/21/2009	119	475	1.44	< 0.000017	< 0.0000718	< 0.0000768	0.000553	NA	32,300	3.2
		1/13/2010	11.1	393	0.94	< 0.0000591	0.000167	0.000217	0.00084	91.04	33,000	3.3
RM11E-ST003	11.3E	9/21/2009	549	1160	14	0.000376	< 0.000204	0.000303	0.00301	NA	21,700	2.2
		1/13/2010	71.9	278	20.4	< 0.000279	< 0.00033	< 0.00025	0.00048	68.51	26,600	2.7
RM11E-ST004	11.5E	9/21/2009	78.6	510	2.8	0.000275	0.000536	0.000358	0.0033	NA	28,200	2.8
		1/14/2010	13.8	918	4.66	< 0.0000815	0.0003025	0.000258	0.00143	44.69	26,200	2.6
RM11E-ST005	11.7E	9/21/2009	22.475 J	308.7 J	< 0.71	NA	NA	NA	NA	NA	NA	NA
		1/14/2010	7.984 J	436.2 J	0.69	< 0.0000638	< 0.0000638	0.000453	0.0023	74	31,700	3.2
RM11E-ST006	11.8E	9/22/2009	22.149 J	487.3 J	1.1 J	0.0004 J	0.0004	0.000422	0.00261	NA	36,200	3.6
		1/13/2010	0.9247 J	255.3 J	2.1 J	< 0.0000496	< 0.0000496	< 0.0000448	0.00037	56	136,000	14
RM11E-ST007	12.1E	9/22/2009	22.646 J	876.4	1.98 J	< 0.0000942	< 0.0000942	< 0.0000919	0.00115	NA	23,600	2.4
		1/14/2010	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

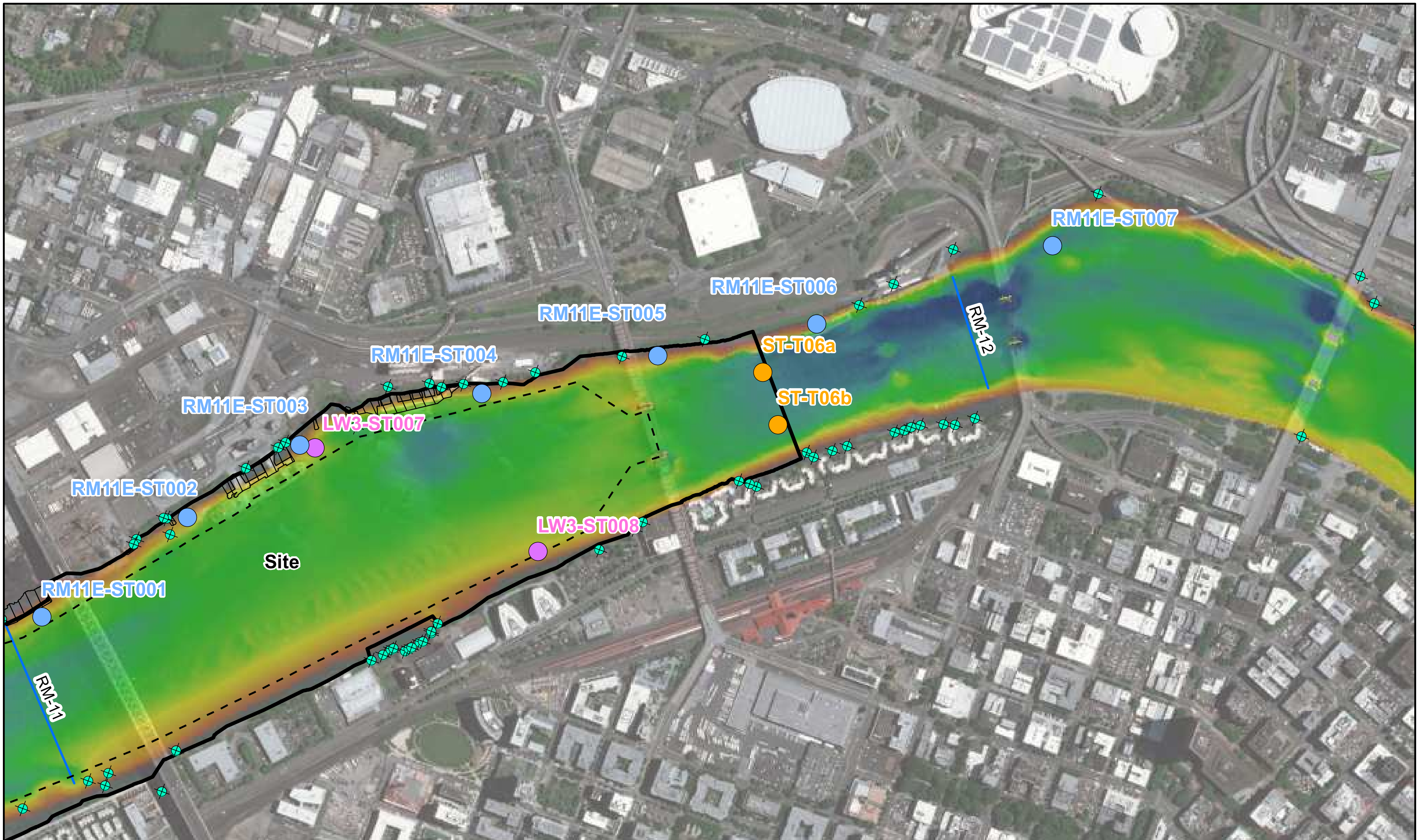
Notes:

1. Sediment traps were deployed for approximately 3 months.
2. NA = not analyzed
3. Total PCBs, Total PAHs, Total DDx and TCDD-TEQs were summed using ND = 0 in the historical database and are included here as reported.
4. < = not detected above MDL
5. During Q3 (9/21/2009), the diver discovered sediment trap RM11E-ST005 lying horizontal on the river bed. Because of the potential for surface sediment accumulation in the trap, the analytical results for RM11E-ST005-Q3 may not necessarily represent settleable suspended sediment quality at this location.

Acronyms:

µg/kg = microgram per kilogram
DDx = sum of dichlorodiphenyltrichloroethane and its derivatives
LWG = Lower Willamette Group
MDL = method detection limit
mg/kg = milligram per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
NR = trap not recovered
PCDD/Fs = polychlorinated dibenzo p dioxins and furans
RM = river mile
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxicity equivalence
TOC = total organic carbon

FIGURES



Legend

- PDI Sediment Trap Location (2018/2019)
- RM 11E Focused Sediment Characterization Sediment Trap Location (2009/2010)
- RI Sediment Trap Location (2006/2007)
- Outfall Location
- River Mile Marker
- Overwater Structures
- Navigation Channel
- Superfund Site Boundary (RM 1.9 to 11.8)

2009 Bathymetric Elevation (ft NAVD88)

High : 11

Low : -90

Notes:
1. Aerial Imagery provided by ESRI Basemaps 2017.
2. Outfall data provided by City of Portland in April 2006.
3. 2009 Bathymetry shown as 2018 bathymetry does not cover downtown reach.

N

0 250 500 1,000 Feet

Sediment Trap Locations Near the Site/Downtown Reach Boundary

Portland Harbor Superfund Site
Sediment Trap Results and Analysis

AECOM Geosyntec consultants

Figure 1

MI/SEA

June 2019

Legend

- PDI Sediment Trap Location (2018/2019)
- RI Sediment Trap Location (2006/2007)
- Outfall Location
- River Mile Marker
- Navigation Channel

Notes:
1. Aerial Imagery provided by ESRI Basemaps 2017.
2. Outfall data provided by City of Portland in April 2006.

Sediment Trap Locations at the Downtown/Upriver Reach Boundary

Portland Harbor Superfund Site
Sediment Trap Results and Analysis

AECOM Geosyntec consultants

MI/SEA | June 2019

Figure 2

Figure 3. Willamette River 2018/2019 Hydrograph and PDI Sediment Trap Deployment Period

General Notes:
1. Flow measured at Morrison Street Bridge RM 12.7, USGS Gage 14211720, daily average calculated based on 15-minute intervals of measured flow.
cfs = cubic feet per second

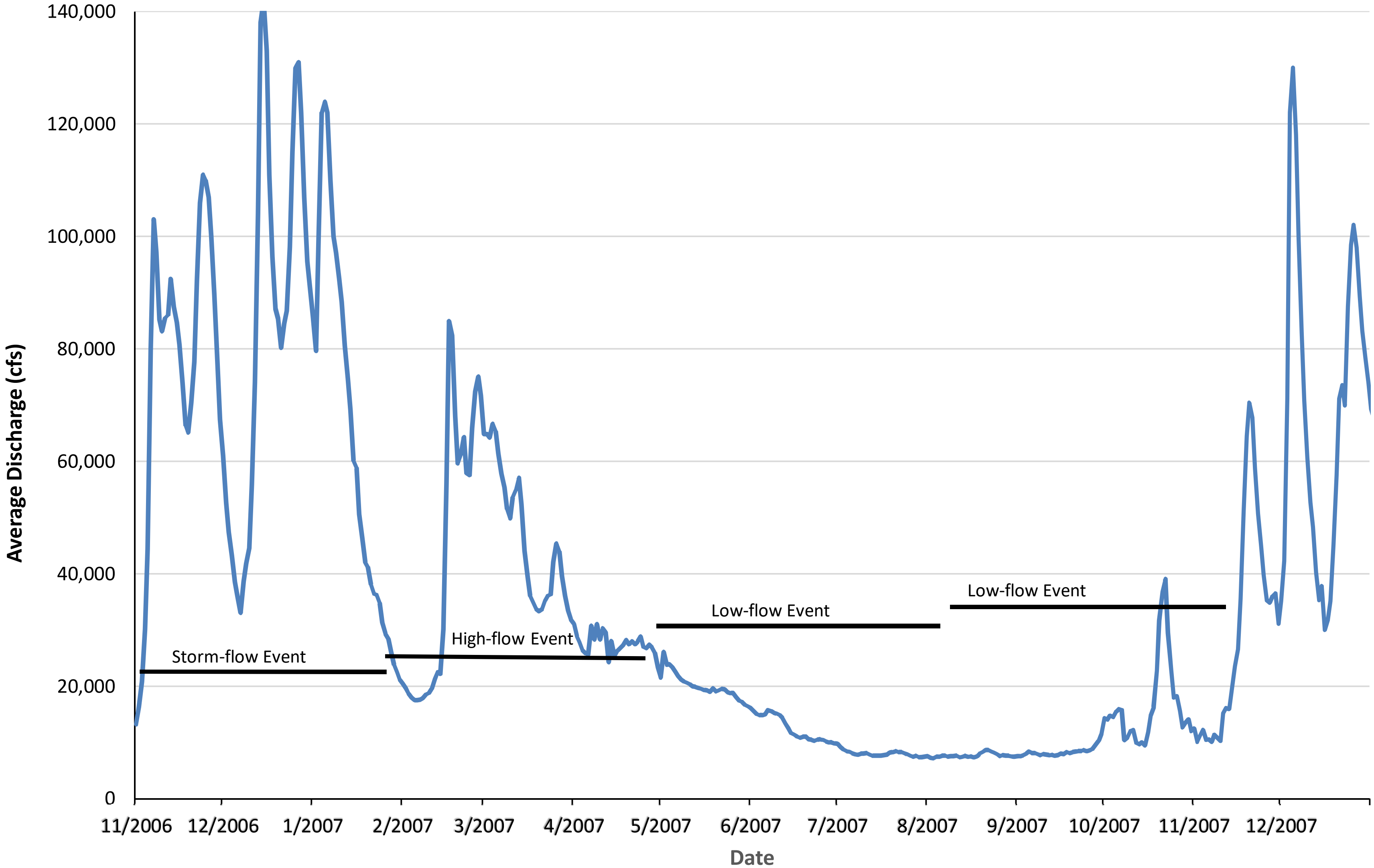


Figure 4. Willamette River 2006-2007 Hydrograph and Historical RI Sediment Trap Deployment Period

General Notes:

1. Flow measured at Morrison Street Bridge RM 12.7, USGS Gage 14211720, daily average calculated based on 15-minute intervals of measured flow).

cfs = cubic feet per second

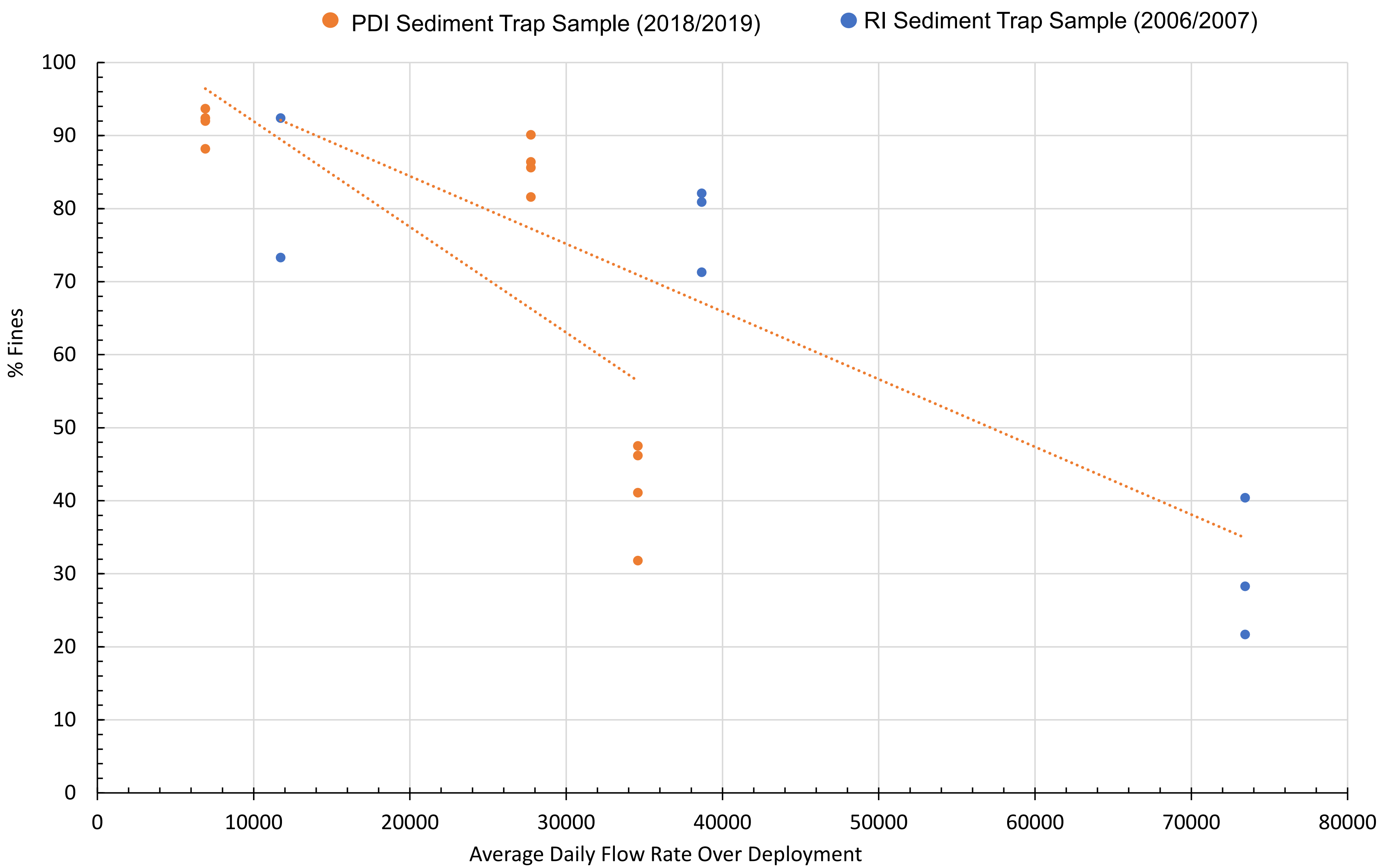


Figure 5. Percent Fines Compared to River Flows

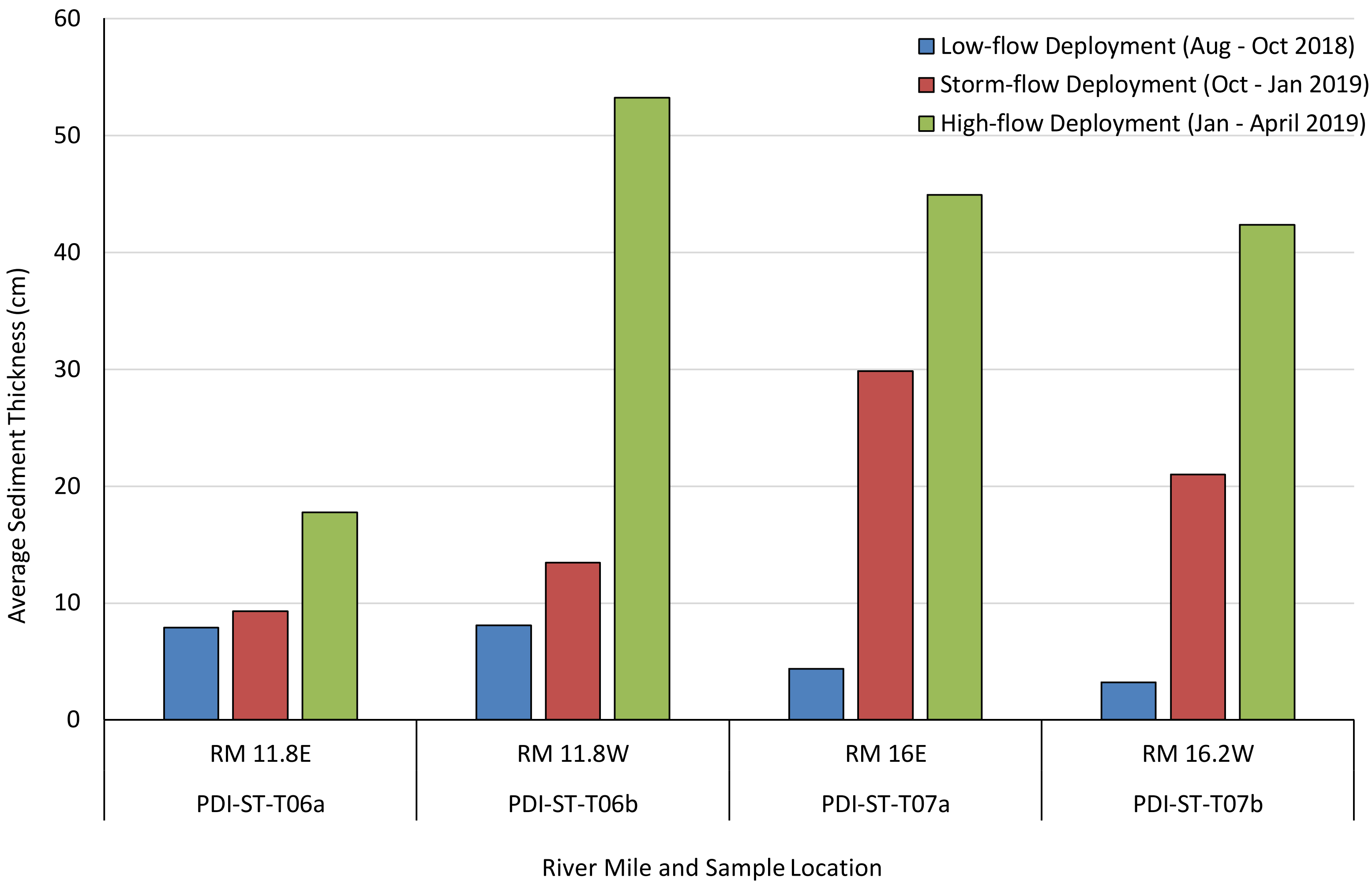


Figure 6. PDI Sediment Trap Average Thickness of Accumulated Sediment

General Note:

1. Average thickness of accumulated sediment in 4 trap cylinders per station. Cylinder heights were 80 cm.

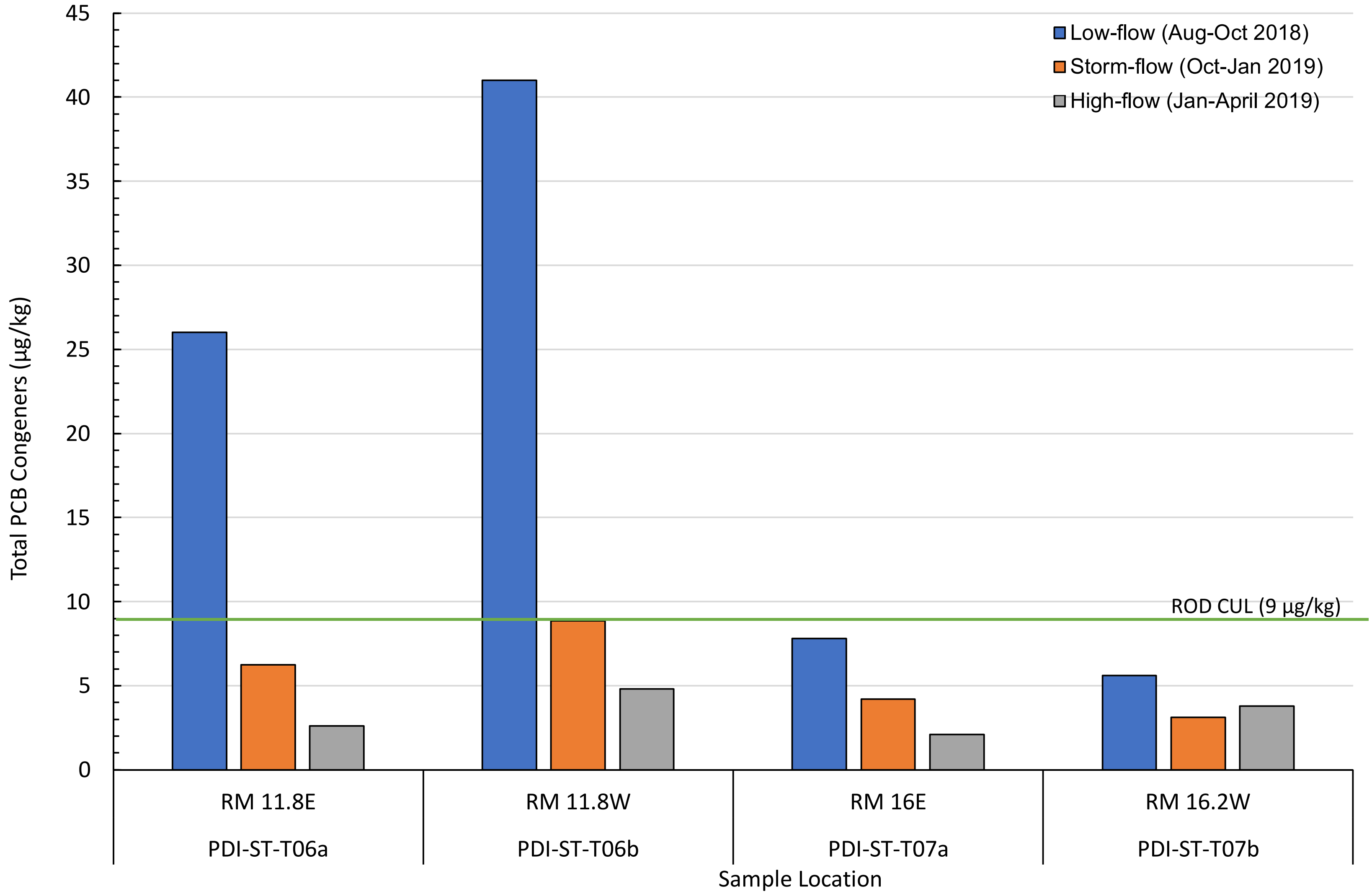


Figure 7a. PDI Sediment Trap Results – Total PCBs

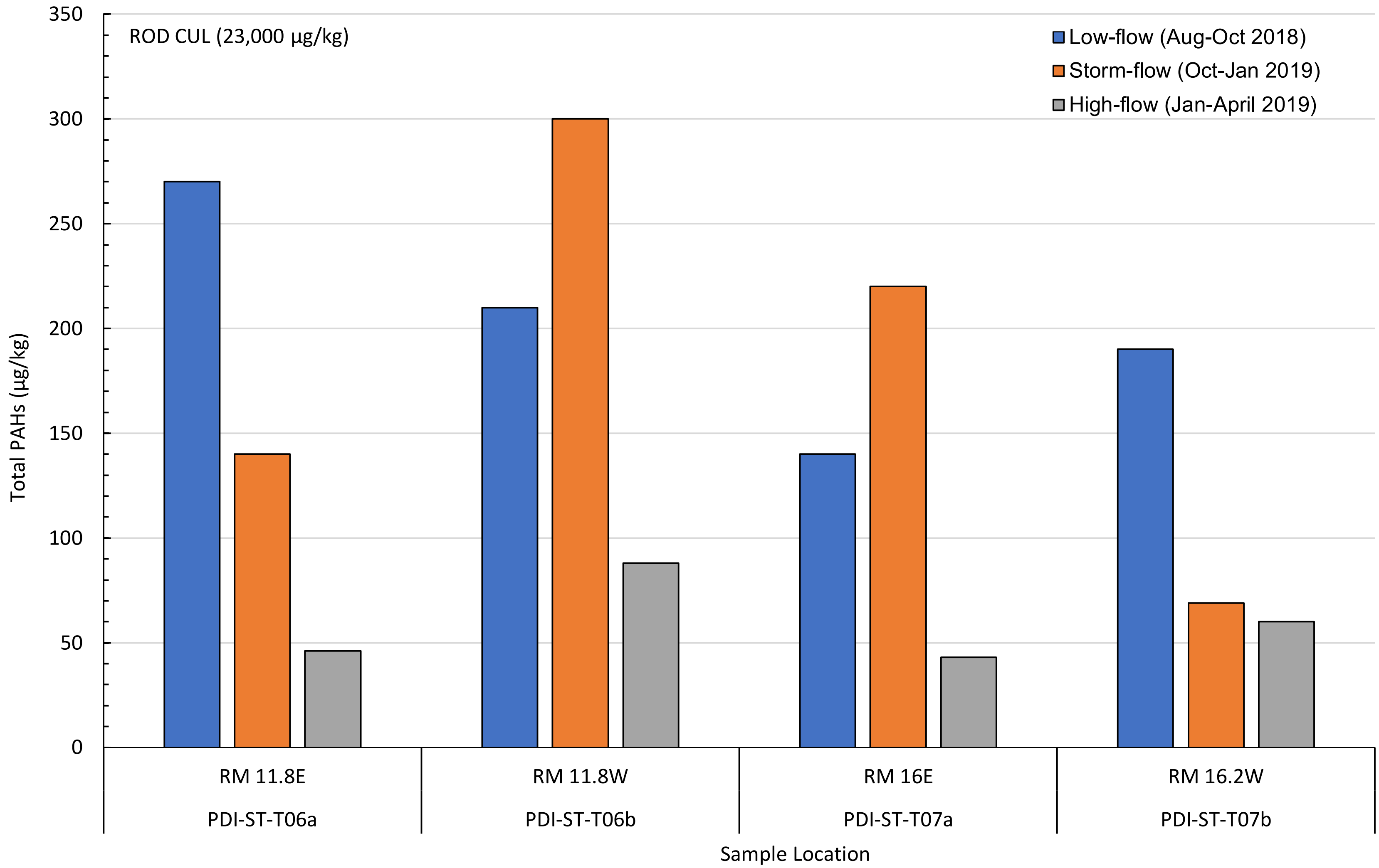


Figure 7b. PDI Sediment Trap Results – Total PAHs

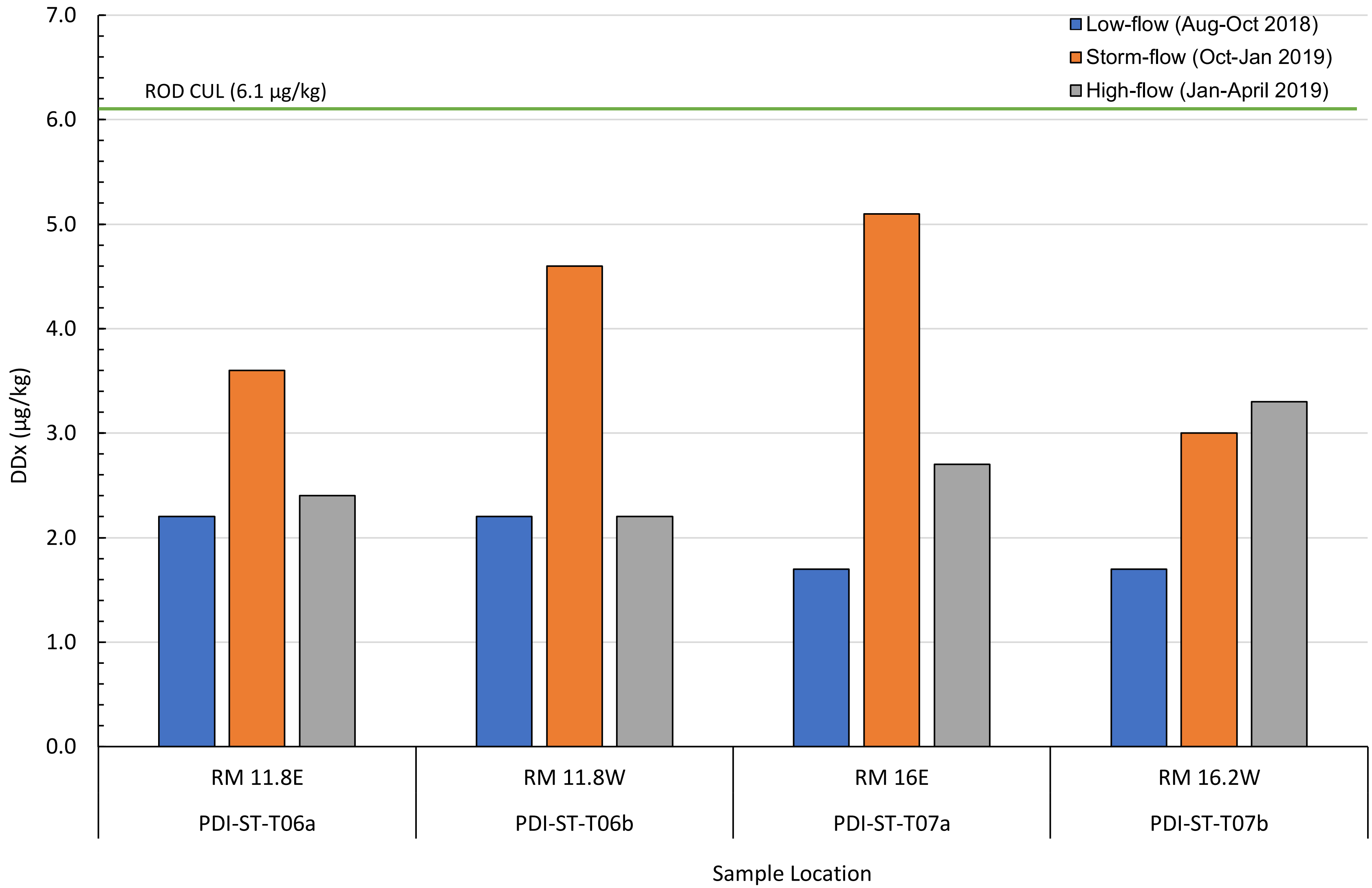


Figure 7c. PDI Sediment Trap Results – DDx

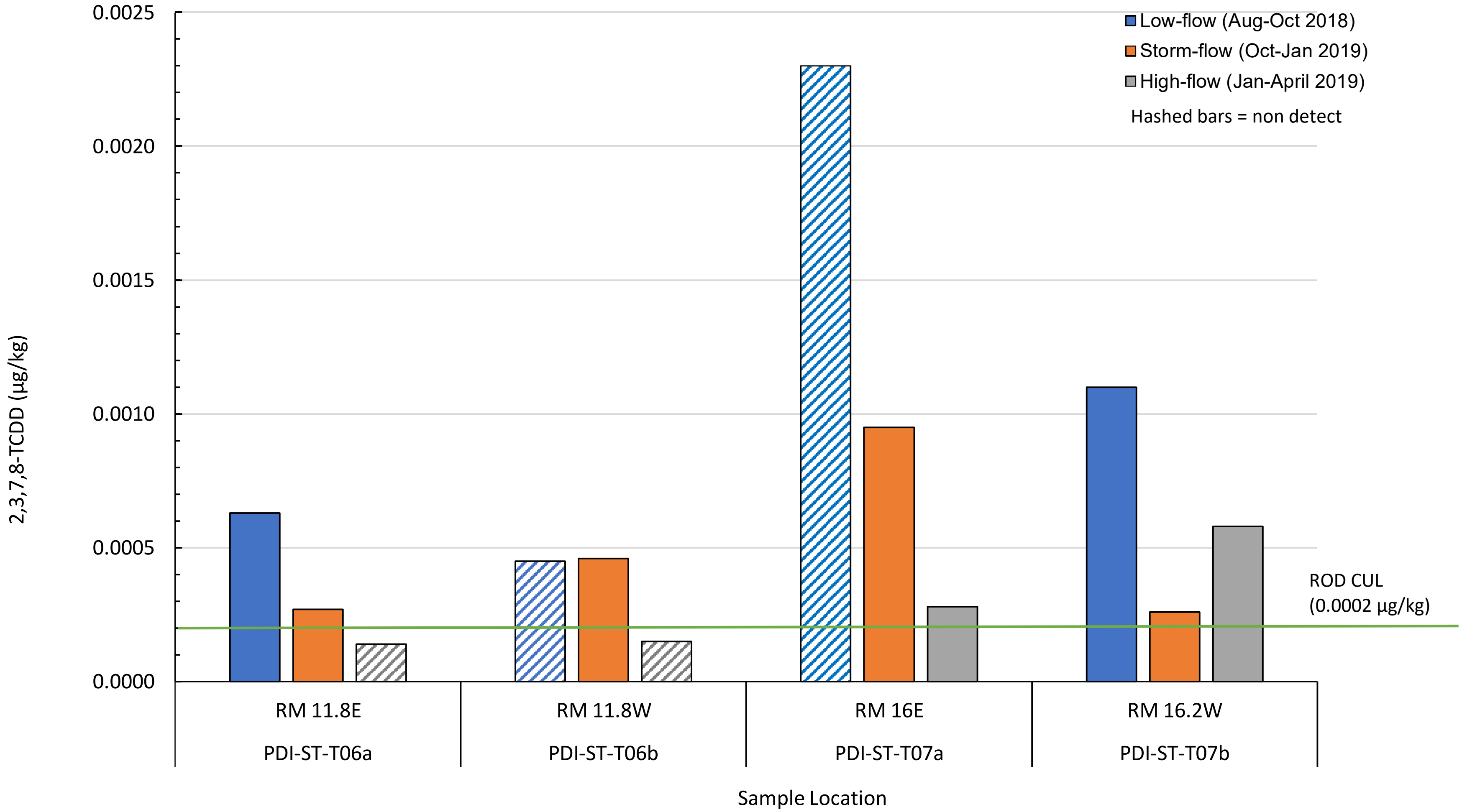


Figure 7d. PDI Sediment Trap Results – 2,3,7,8-TCDD

General Notes:

1. Non-detect data are shown as hashed bars.

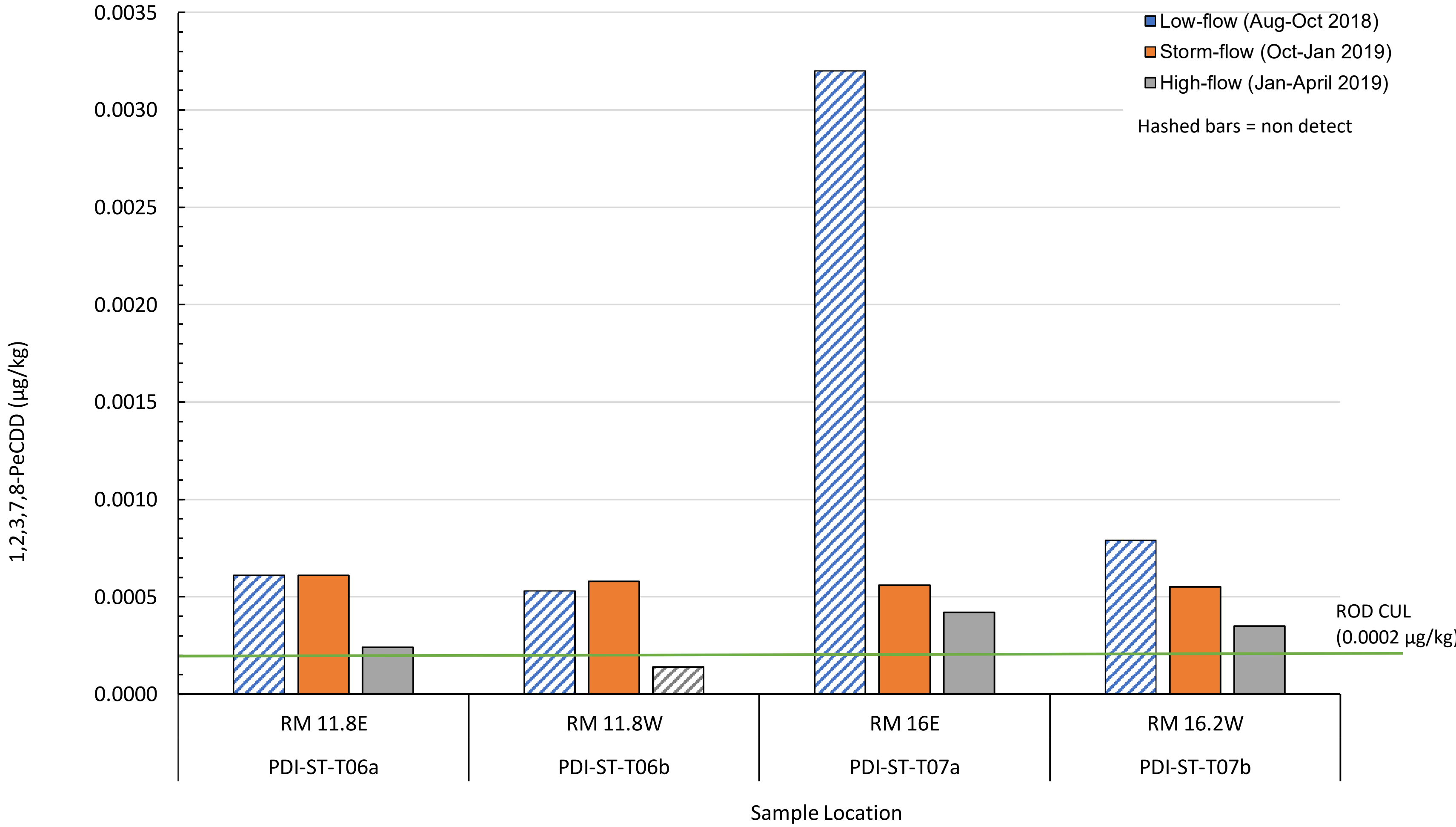


Figure 7e. PDI Sediment Trap Results – 1,2,3,7,8-PeCDD

General Notes:

1. Non-detect data are shown as hashed bars.

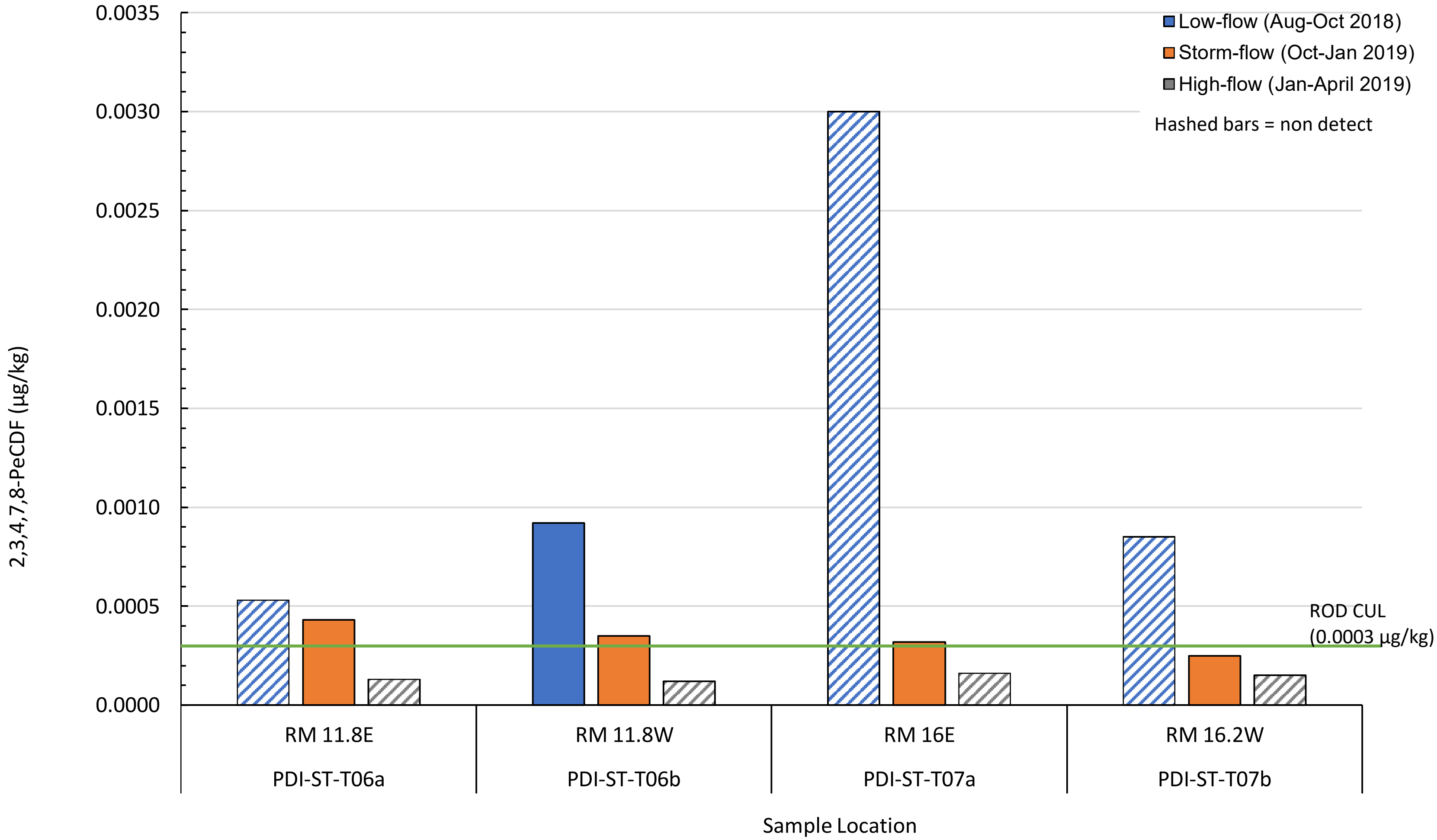


Figure 7f. PDI Sediment Trap Results – 2,3,4,7,8-PeCDF

General Notes:

1. Non-detect data are shown as hashed bars.

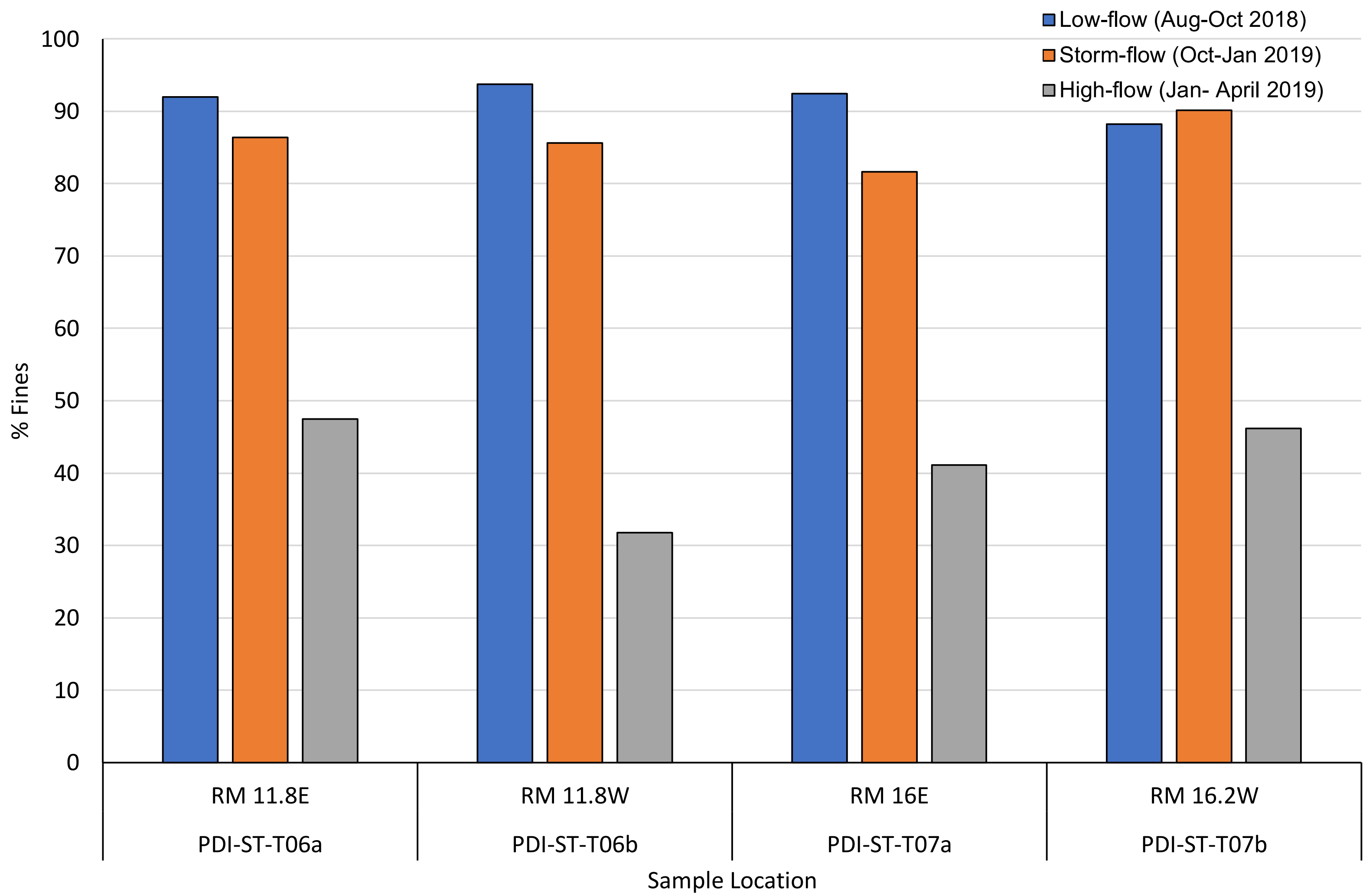


Figure 7g. PDI Sediment Trap Results – Percent Fines

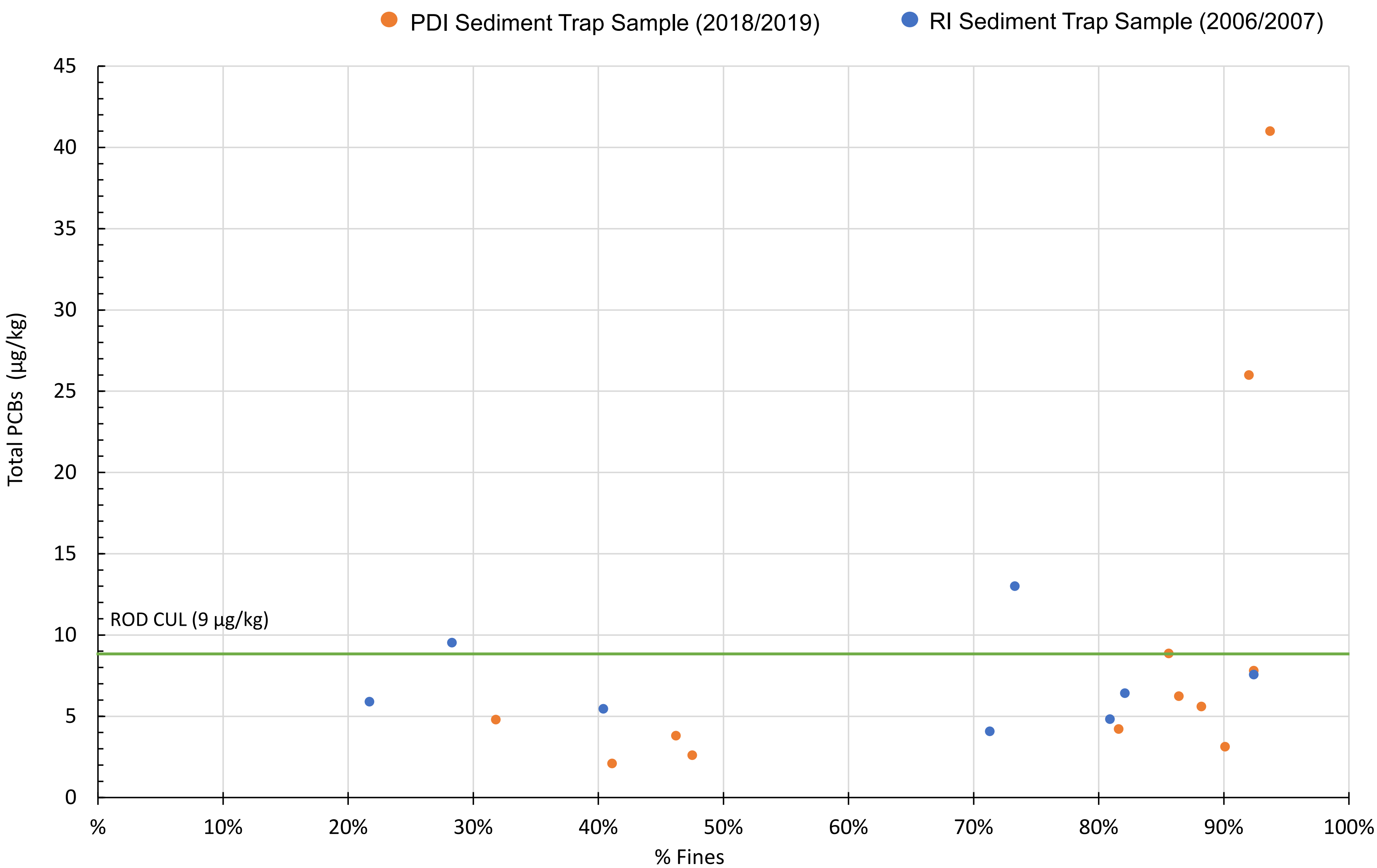


Figure 8a. Scatterplot PCB Results versus Percent Fines

General Notes:

1. Non-detect data are shown as open circles.

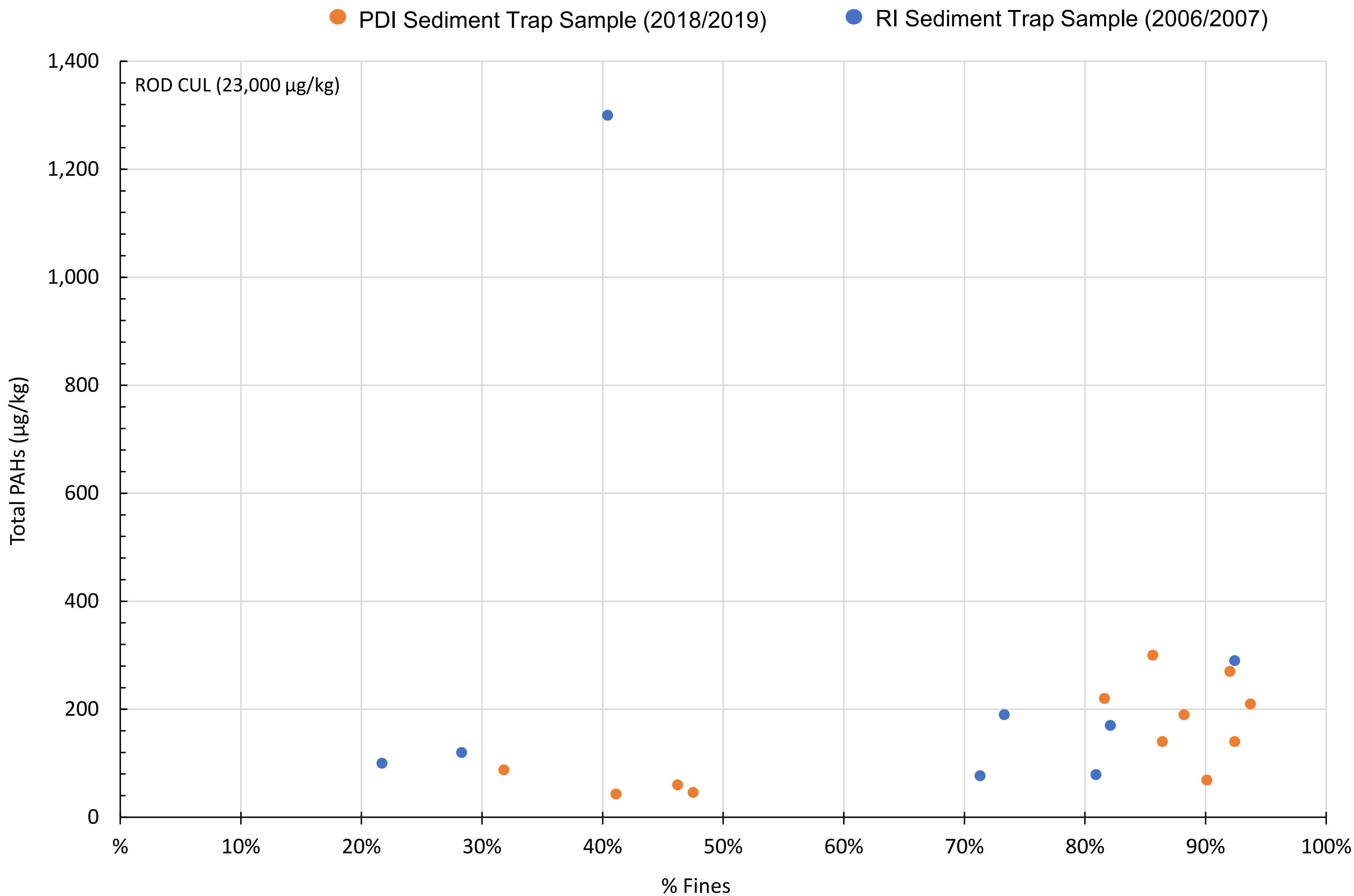


Figure 8b. Scatterplot PAH Results versus Percent Fines

General Notes:

1. Non-detect data are shown as open circles.

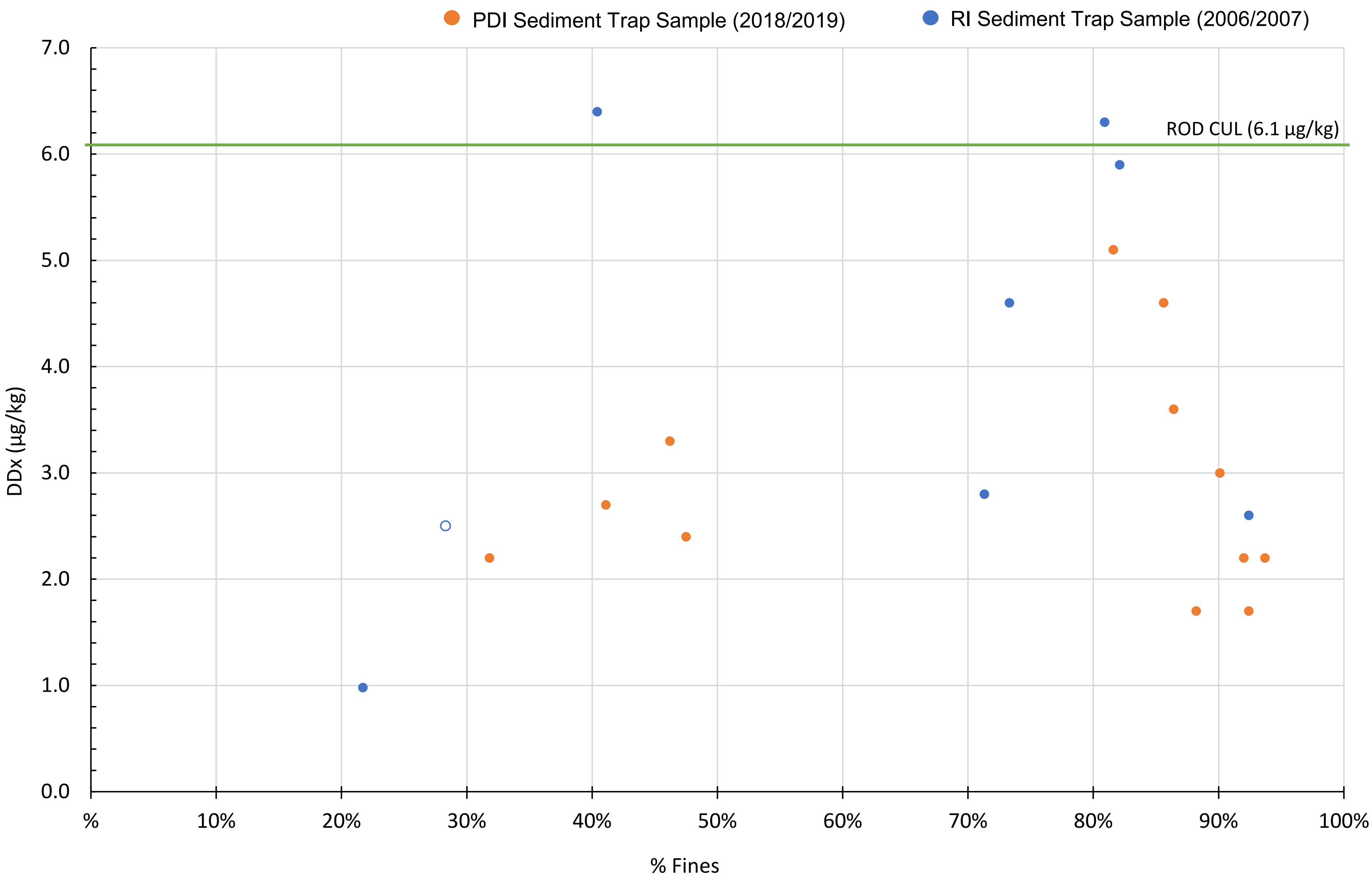


Figure 8c. Scatterplot DDx Results versus Percent Fines

General Notes:

1. Non-detect data are shown as open circles.

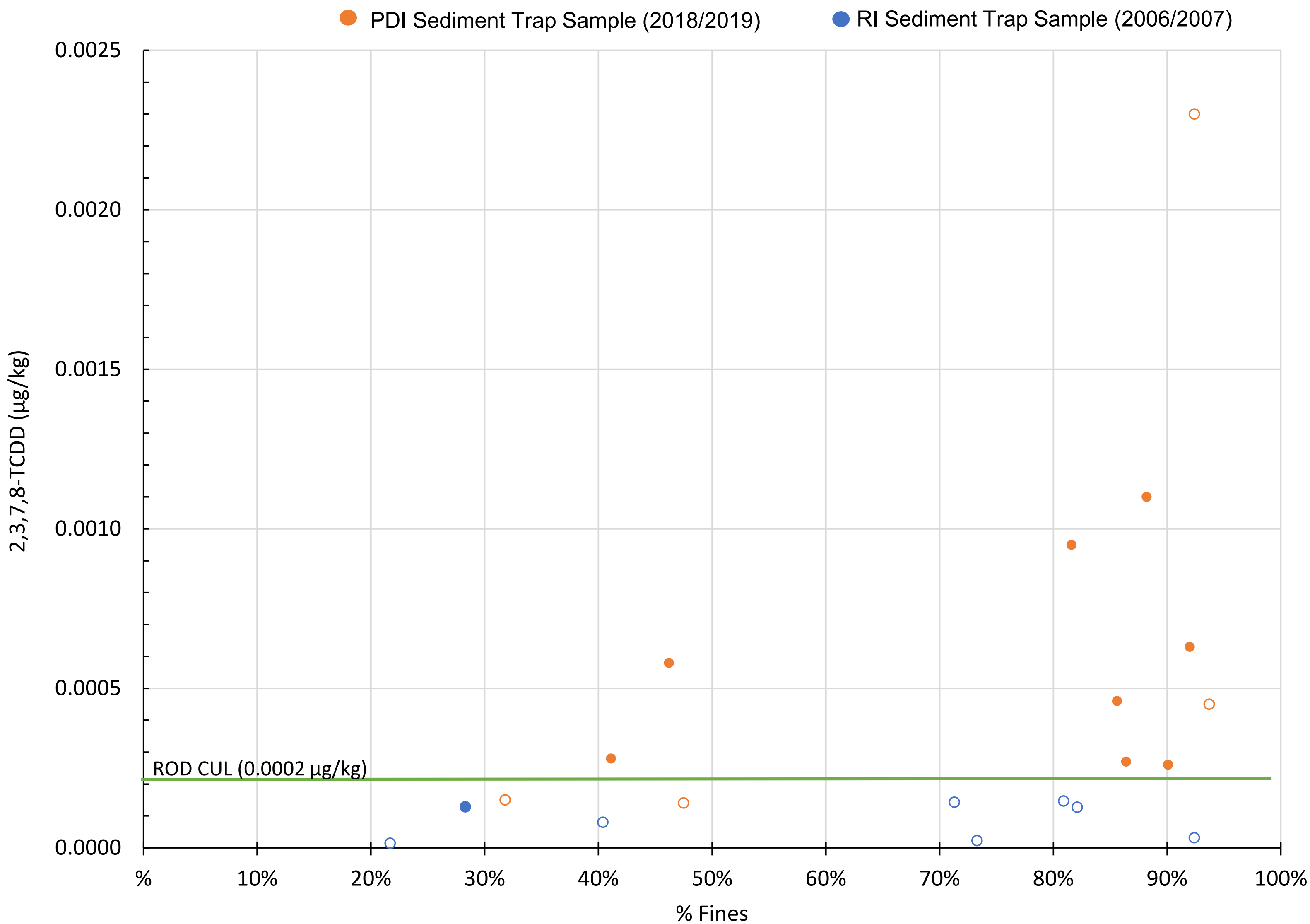


Figure 8d. Scatterplot 2,3,7,8-TCDD Results versus Percent Fines

General Notes:

1. Non-detect data are shown as open circles.

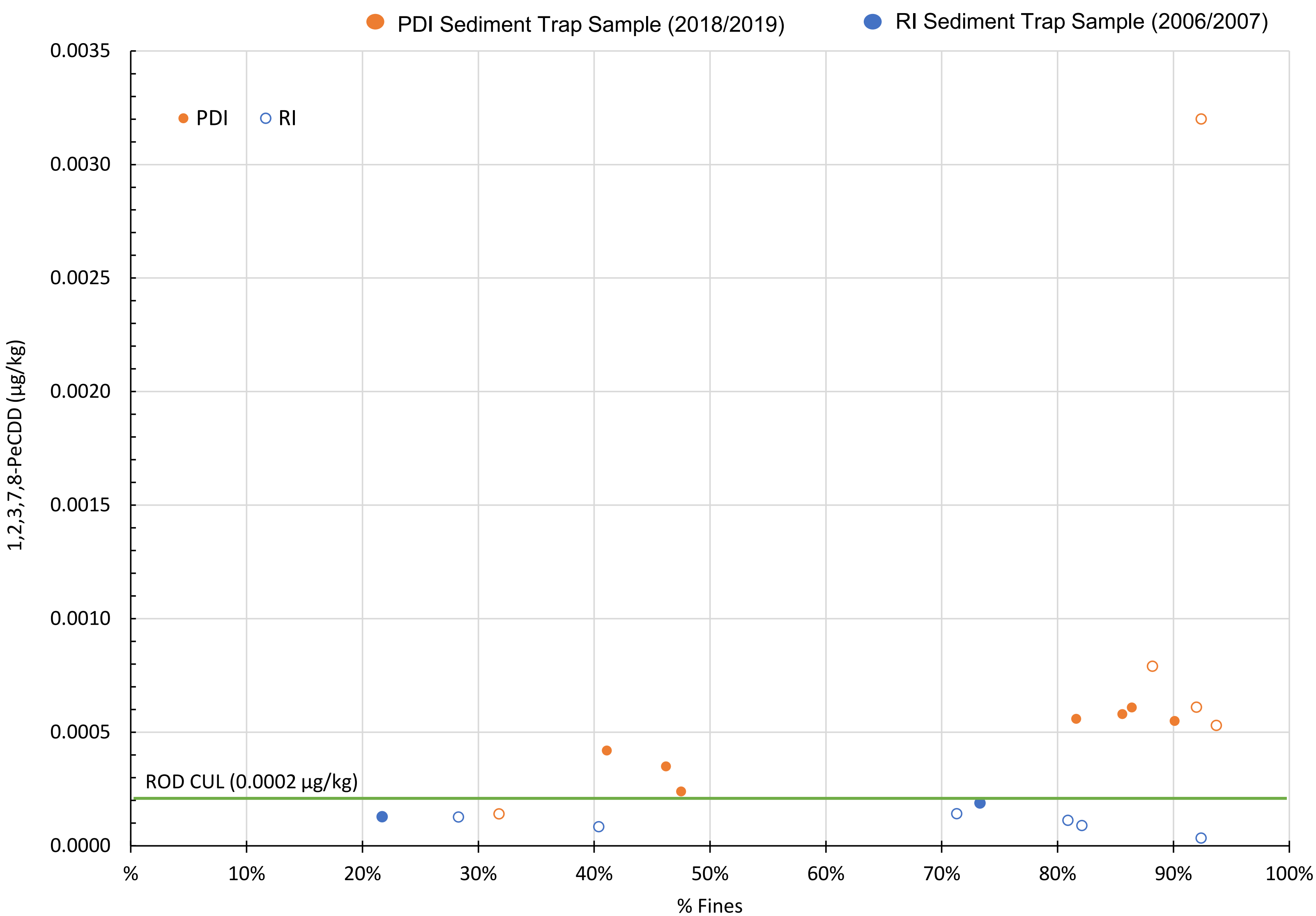


Figure 8e. Scatterplot 1,2,3,7,8-PeCDD Results versus Percent Fines

General Notes:

1. Non-detect data are shown as open circles.

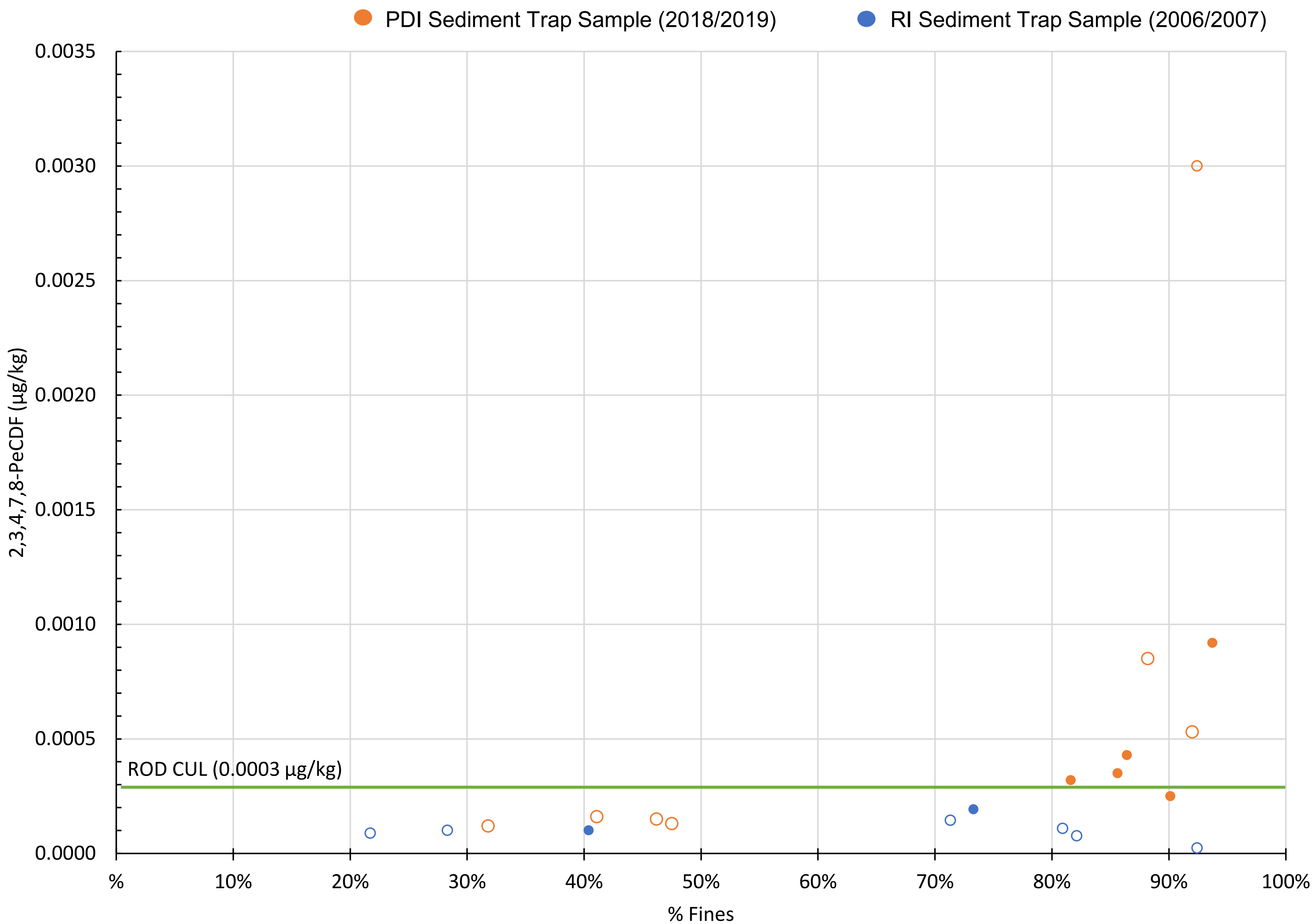


Figure 8f. Scatterplot 2,3,4,7,8-PeCDF Results versus Percent Fines

General Notes:

1. Non-detect data are shown as open circles.

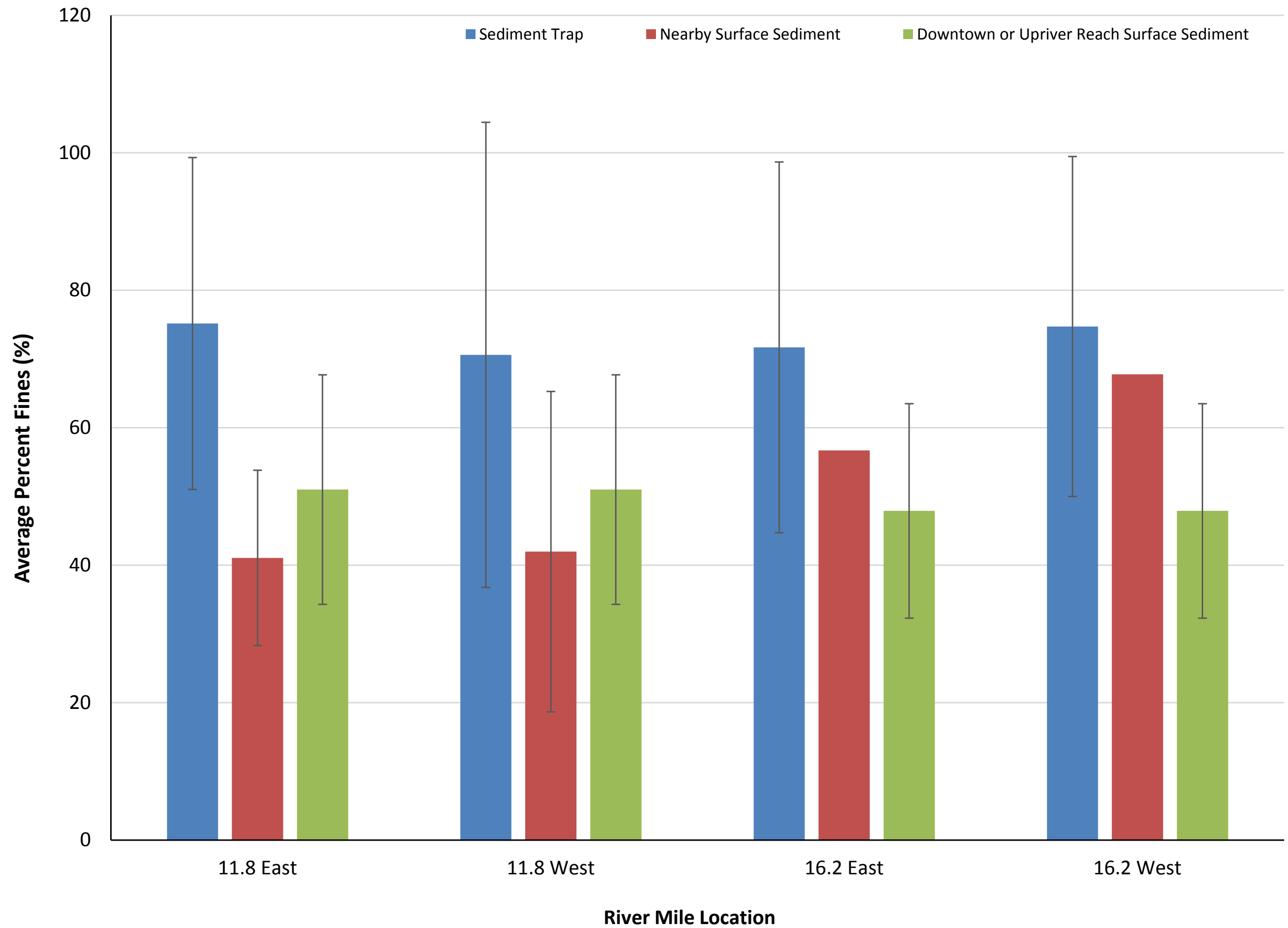


Figure 9a. Average PDI Sediment Trap Results Compared to PDI Surface Sediment Samples - Percent Fines

General Notes:
1. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.
2. Sediment trap data represent the average of PDI low-flow, storm-flow and high-flow events.
3. Nearby surface sediment data represent the average of the closest 2 to 3 2018 PDI surface sediment grab samples.
4. Average of Downtown Reach surface sediment samples shown for RM 11.8 locations. Average of Upriver Reach sediment shown for RM 16.2 locations.

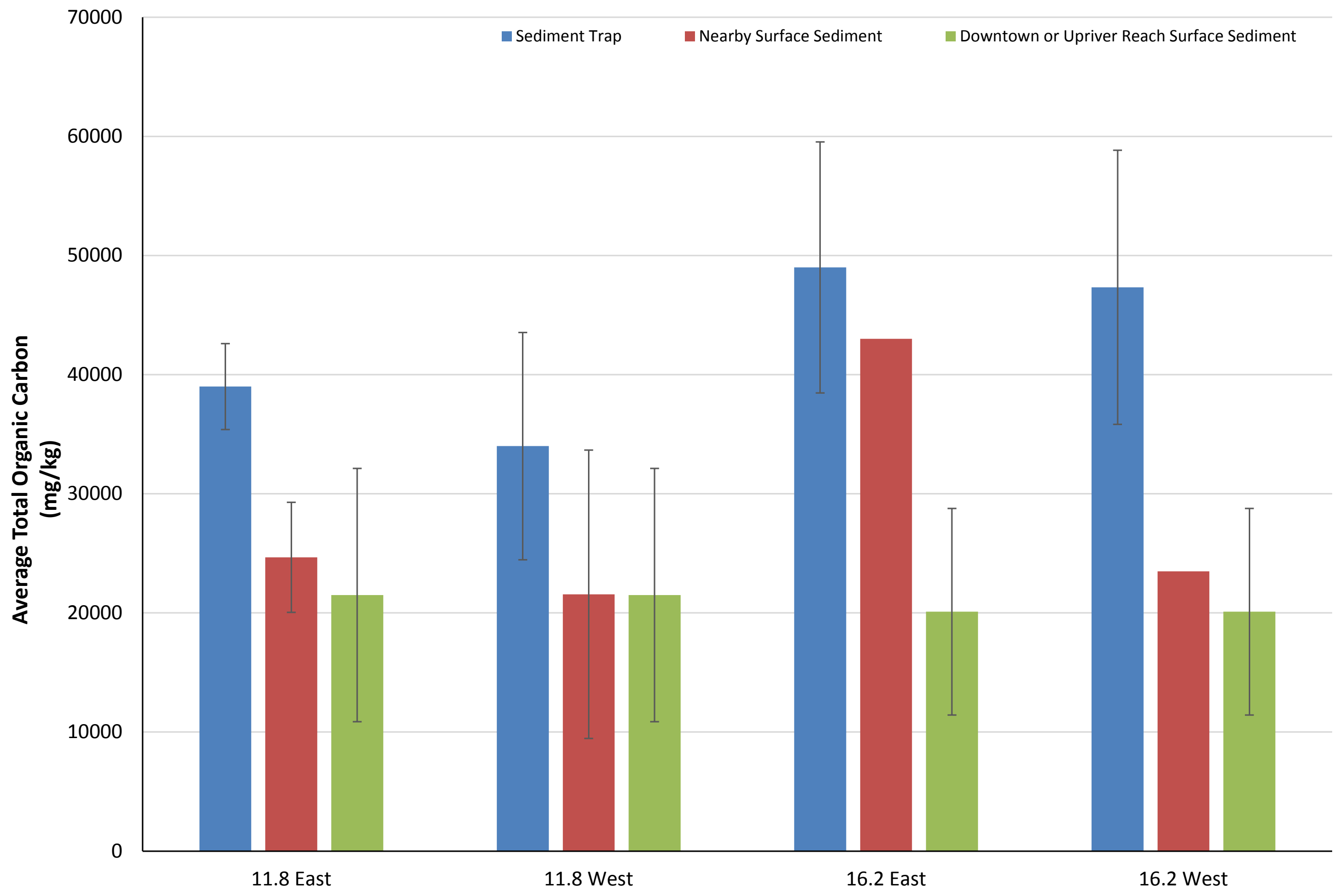


Figure 9b. Average PDI Sediment Trap Results Compared to PDI Surface Sediment Samples - Total Organic Carbon

Notes:
1. Error bars represent 1 standard deviation of the mean and are presented when n = 3 or greater.
2. Sediment trap data represent the average of PDI low-flow, storm-flow and high-flow events.
3. Nearby surface sediment data represent the average of the closest 2 to 3 2018 PDI surface sediment grab samples.
4. Average of Downtown Reach surface sediment samples shown for RM 11.8 locations. Average of Upriver Reach sediment shown for RM 16.2 locations.

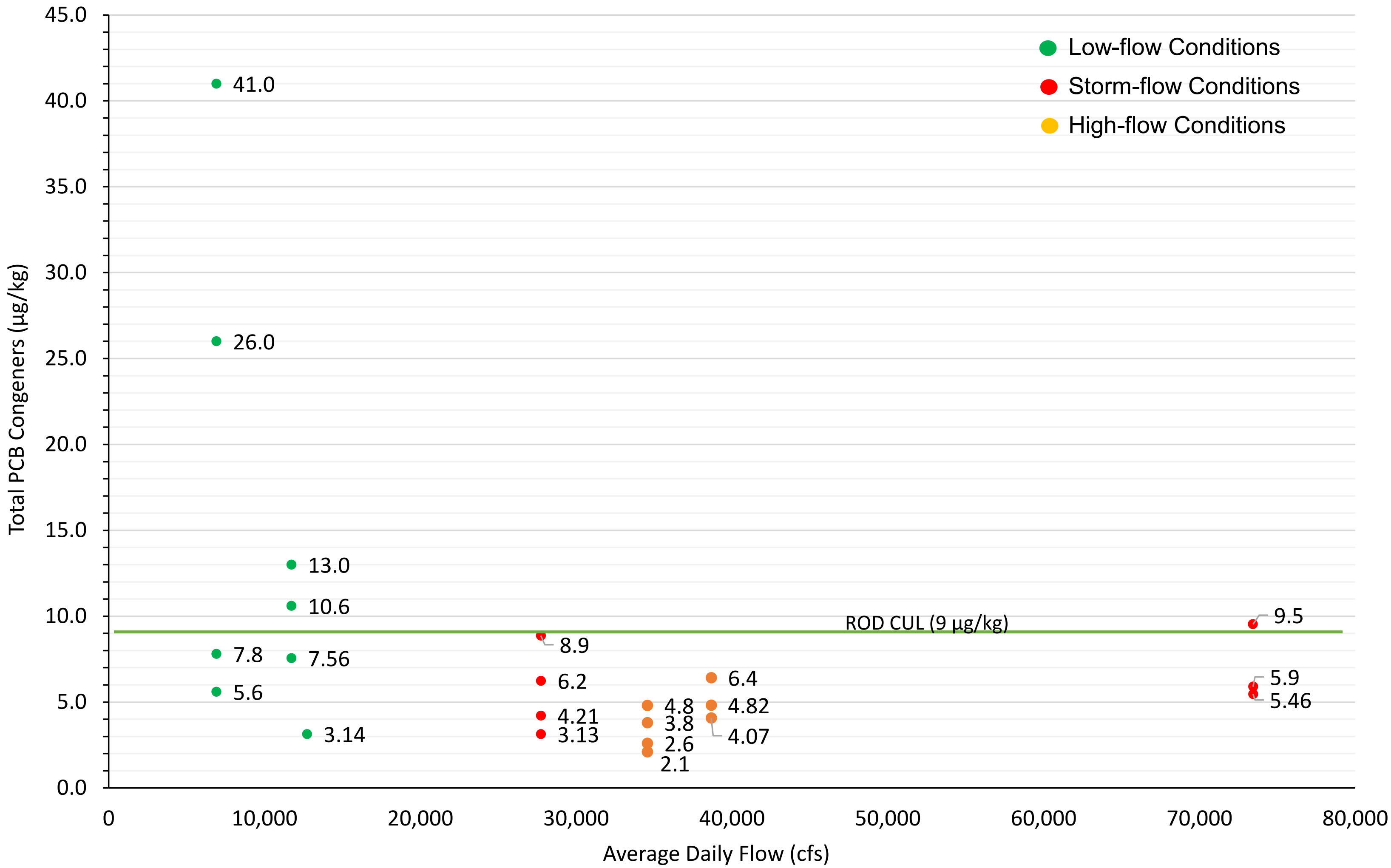


Figure 10a. Scatterplot Total PCB Results versus River Flows

General Notes:

1. Data include RI low-flow, storm-flow and high-flow events (data for ST007 at RM11.3 not shown as not representative of Upstream conditions) and PDI low-flow, storm-flow and high-flow events.
2. Open symbols indicate results below the detection limits and are shown at the method detection limit.

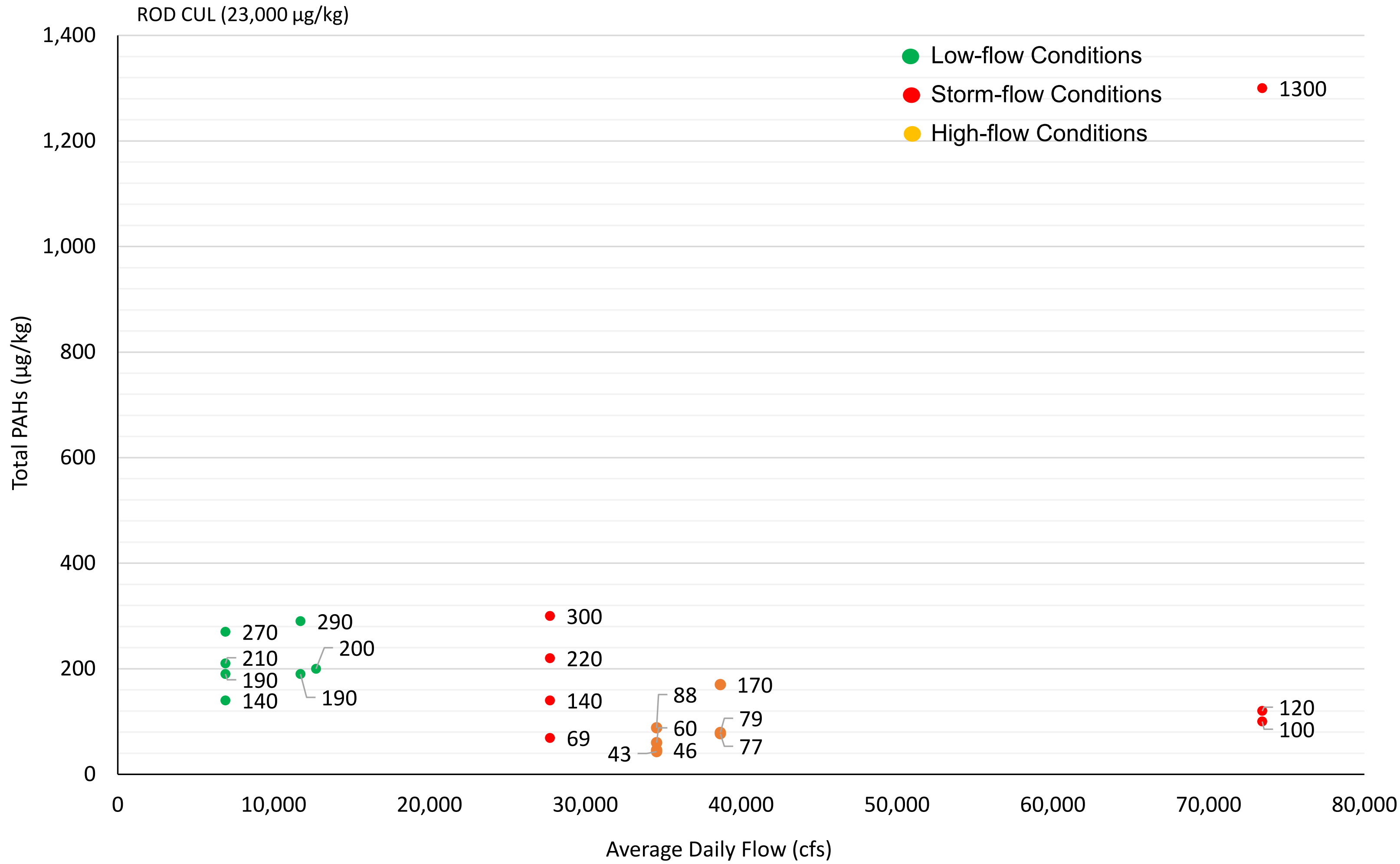


Figure 10b. Scatterplot Total PAH Results versus River Flows

General Notes:

1. Data include RI low-flow, storm-flow and high-flow events (data for ST007 at RM11.3 not shown as not representative of Upstream conditions) and PDI low-flow, storm-flow and high-flow events.
2. Open symbols indicate results below the detection limits and are shown at the method detection limit.

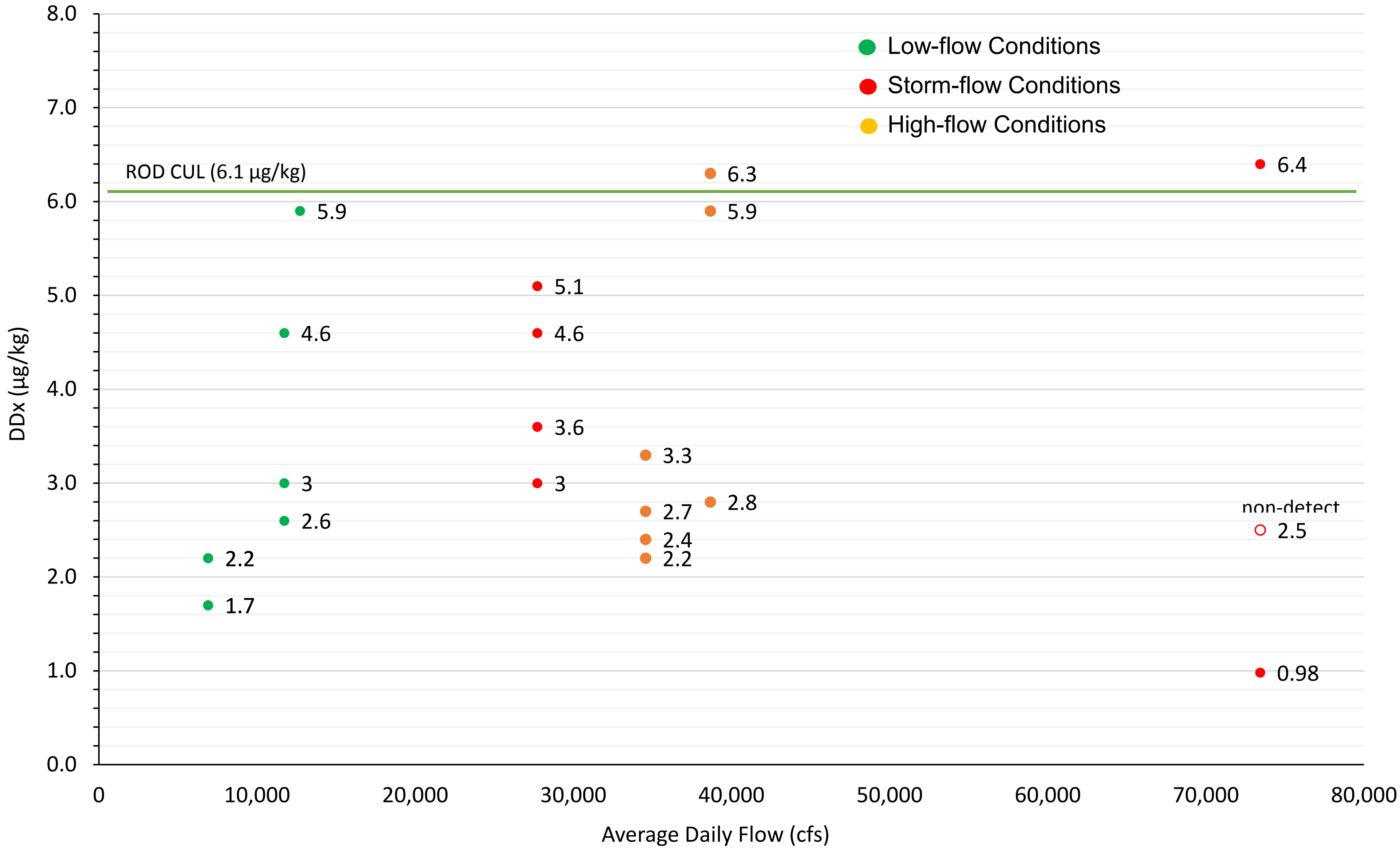


Figure 10c. Scatterplot DDx Results versus River Flows

General Notes:
1. Data include RI low-flow, storm-flow and high-flow events (data for ST007 at RM11.3 not shown as not representative of Upstream conditions) and PDI low-flow, storm-flow and high-flow events.
2. Open symbols indicate results below the detection limits and are shown at the method detection limit.

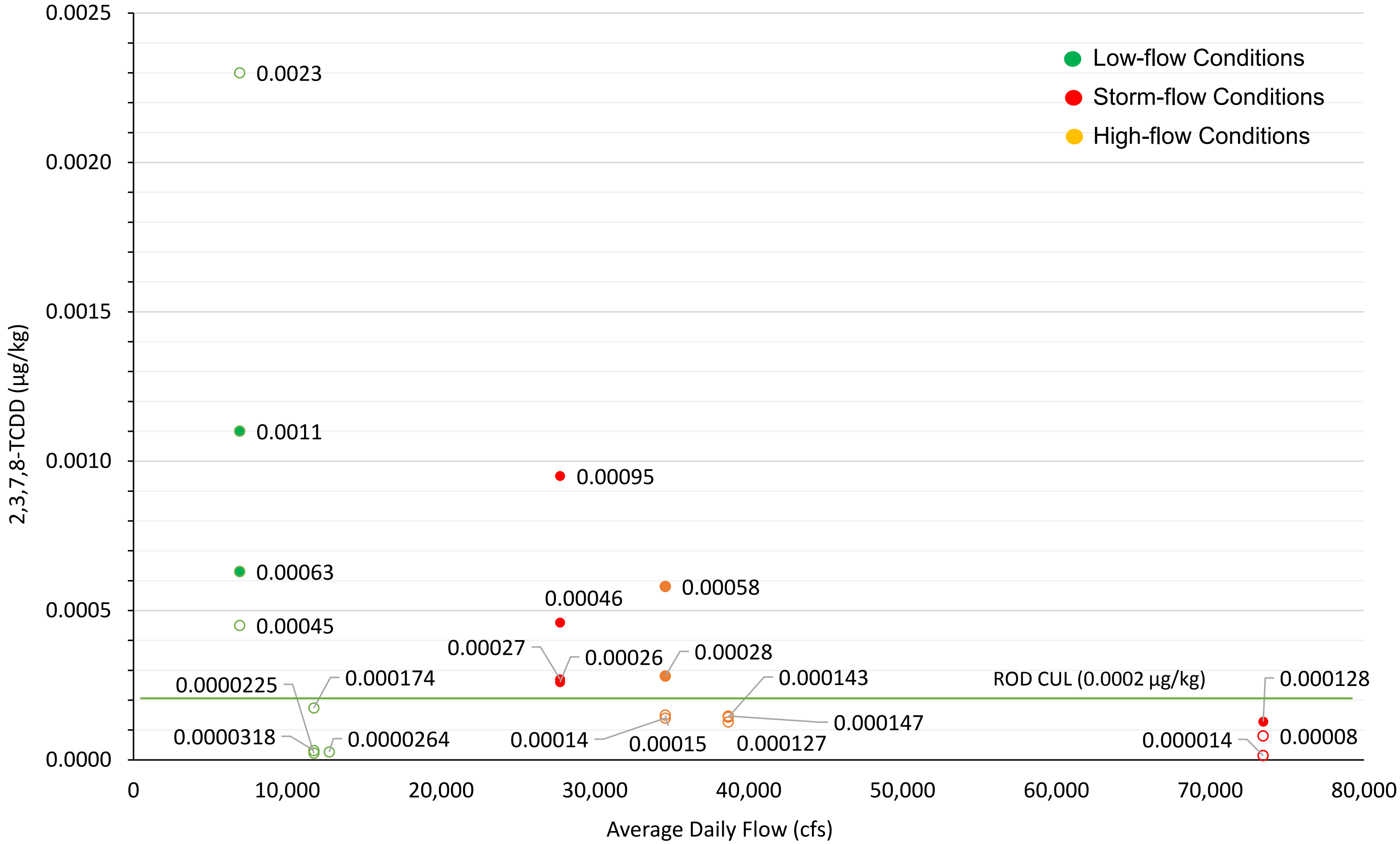


Figure 10d. Scatterplot 2,3,7,8-TCDD Results versus River Flows

General Notes:

1. Data include RI low-flow, storm-flow and high-flow events (data for ST007 at RM11.3 not shown as not representative of Upstream conditions) and PDI low-flow, storm-flow and high-flow events.
2. Open symbols indicate results below the detection limits and are shown at the method detection limit.

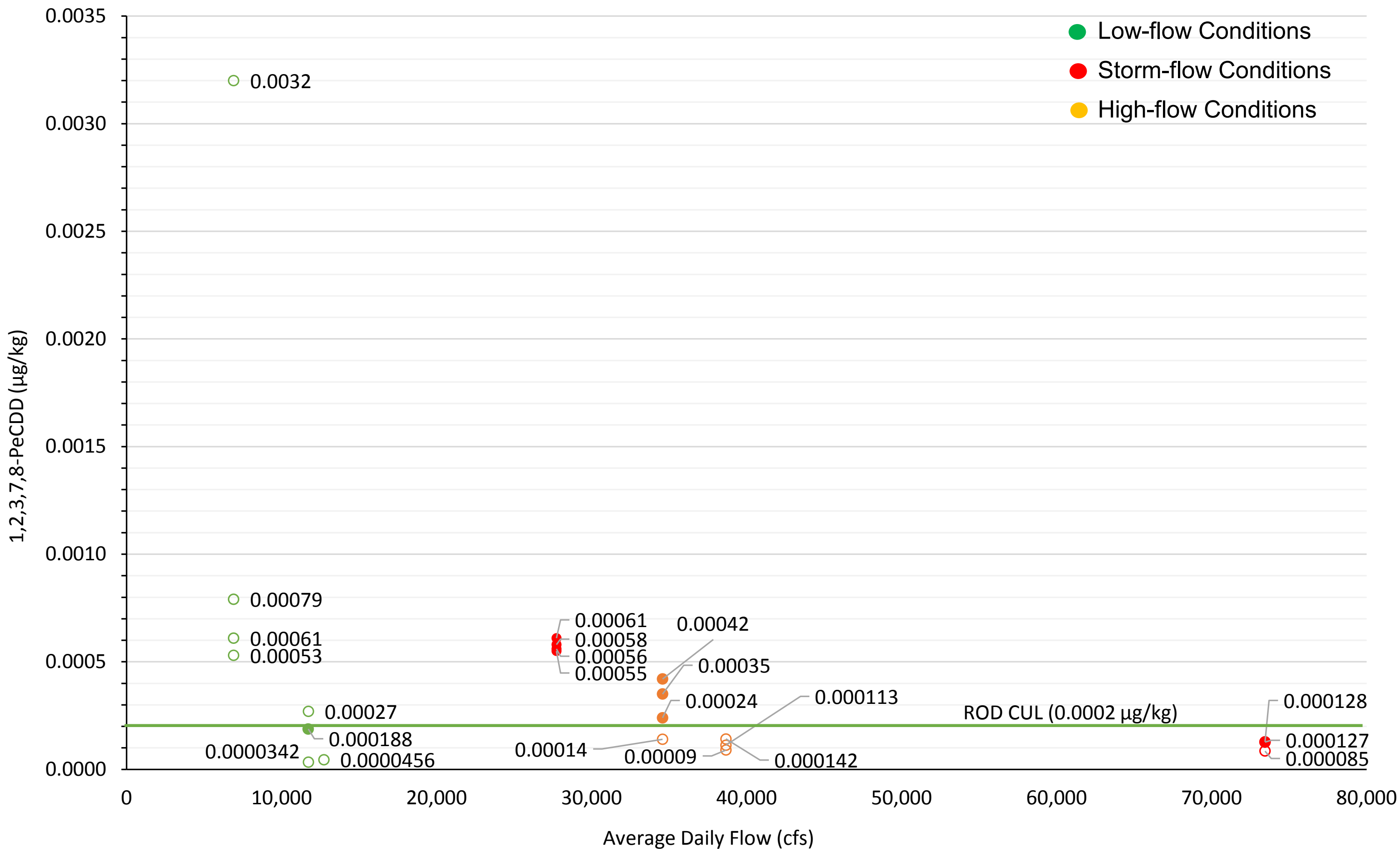


Figure 10e. Scatterplot 1,2,3,7,8-PeCDD Results versus River Flows

General Notes:

1. Data include RI low-flow, storm-flow and high-flow events (data for ST007 at RM11.3 not shown as not representative of Upstream conditions) and PDI low-flow, storm-flow, and high-flow events.
2. Open symbols indicate results below the detection limits and are shown at the method detection limit.

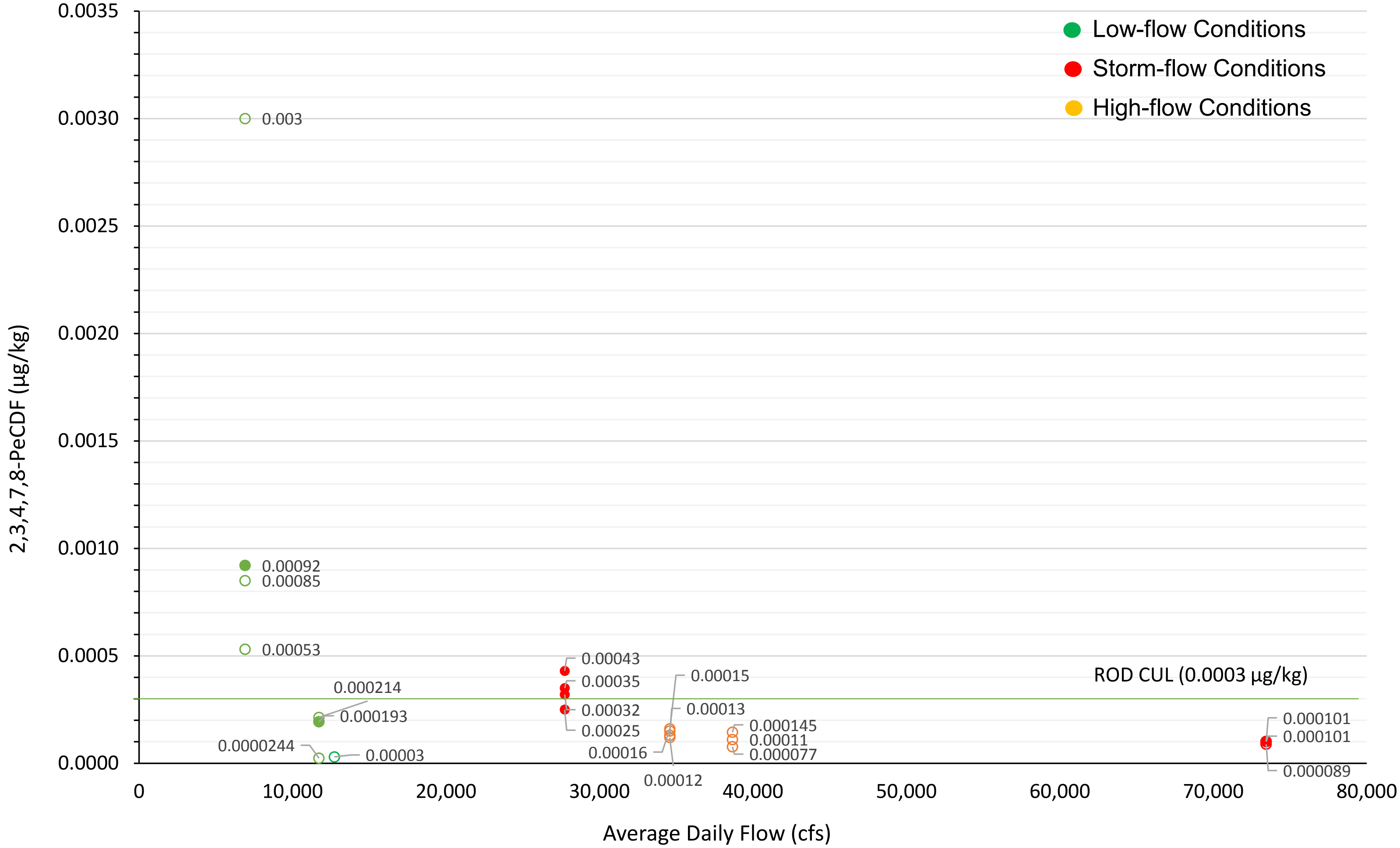


Figure 10f. Scatterplot 2,3,4,7,8-PeCDF Results versus River Flows

General Notes:

1. Data include RI low-flow, storm-flow and high-flow events (data for ST007 at RM11.3 not shown as not representative of Upstream conditions) and PDI low-flow, storm-flow and high-flow events.
2. Open symbols indicate results below the detection limits and are shown at the method detection limit.

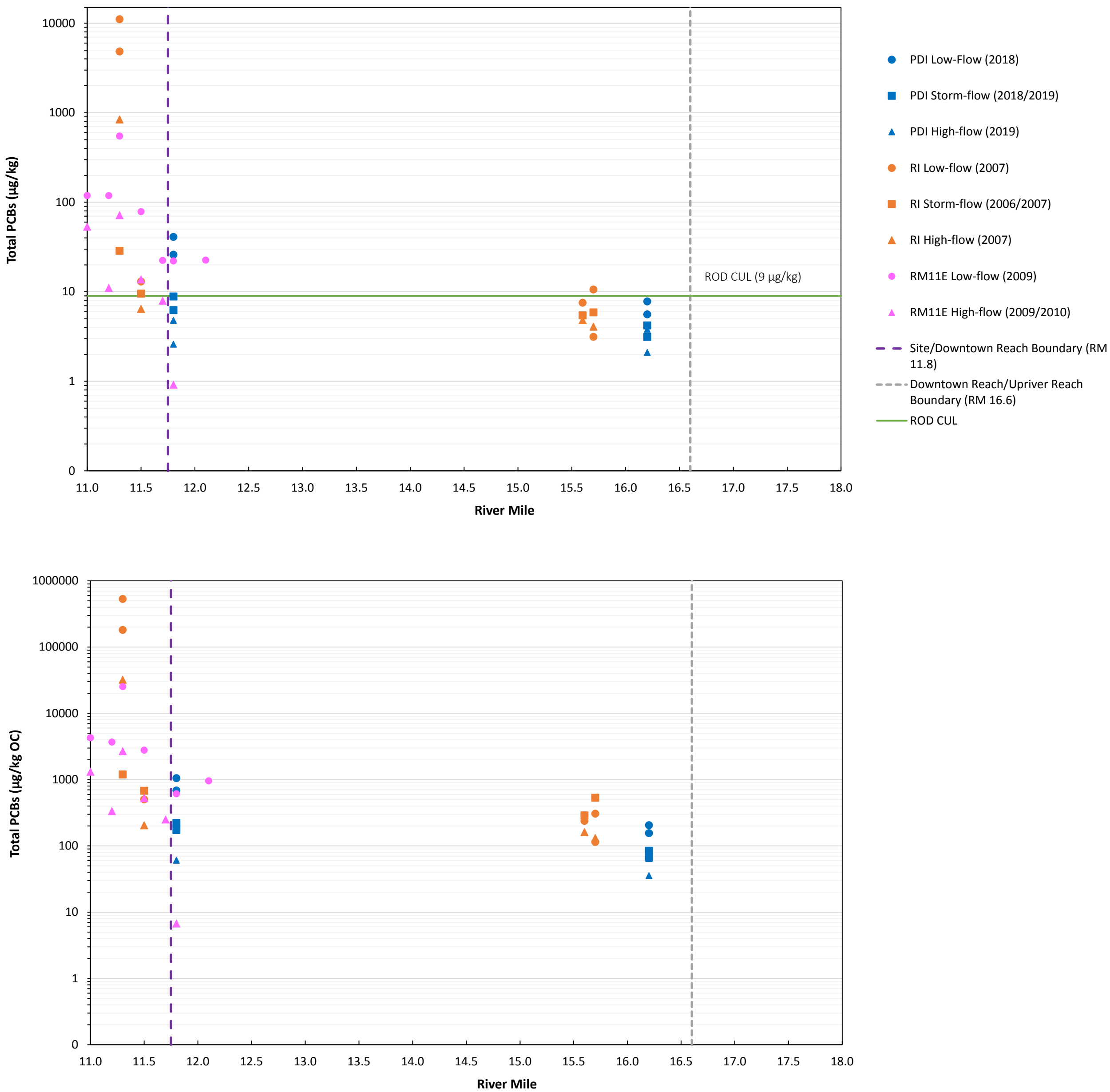


Figure 11a. Comparison of 2006/2007 RI, 2009/2010 RM11E, and 2018/2019 Sediment Trap Results

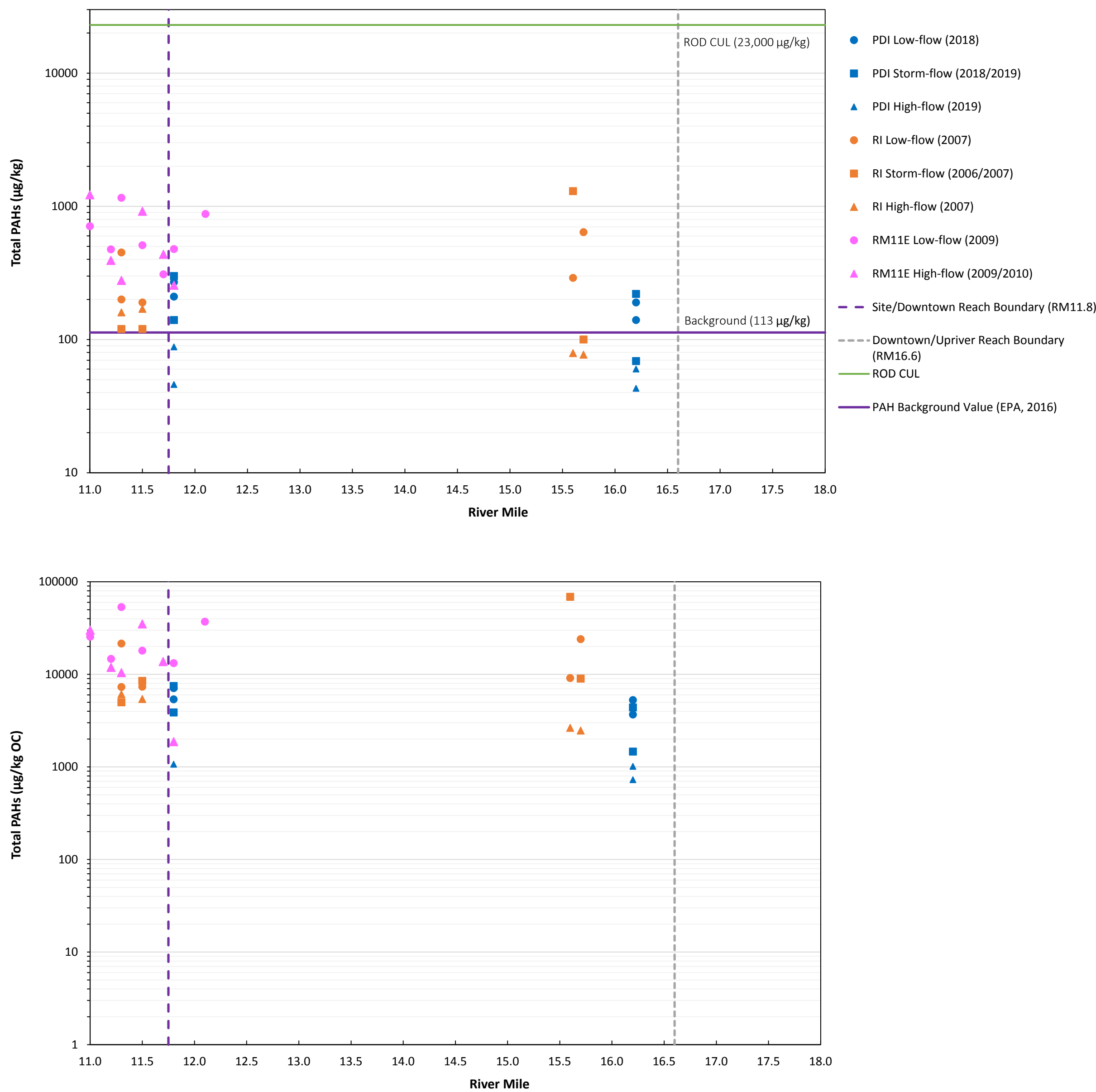
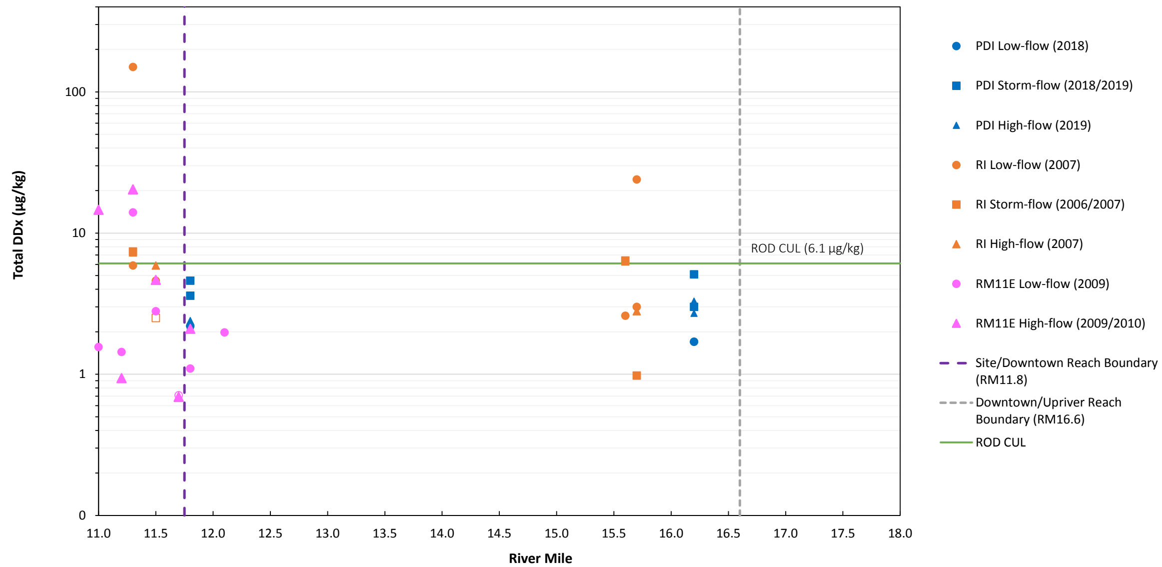


Figure 11b. Comparison of 2006/2007 RI, 2009/2010 RM11E, and 2018/A12019 Sediment Trap Results – Total PAHs



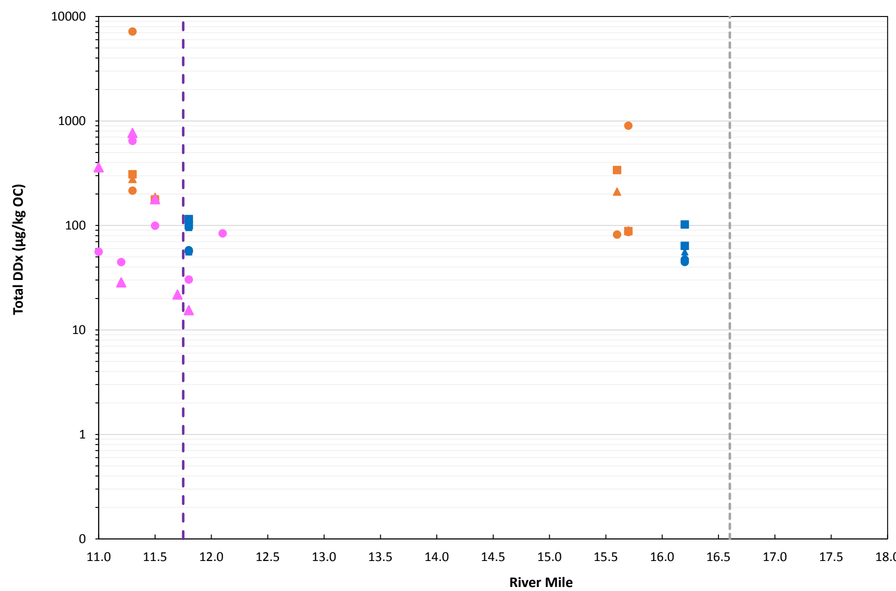
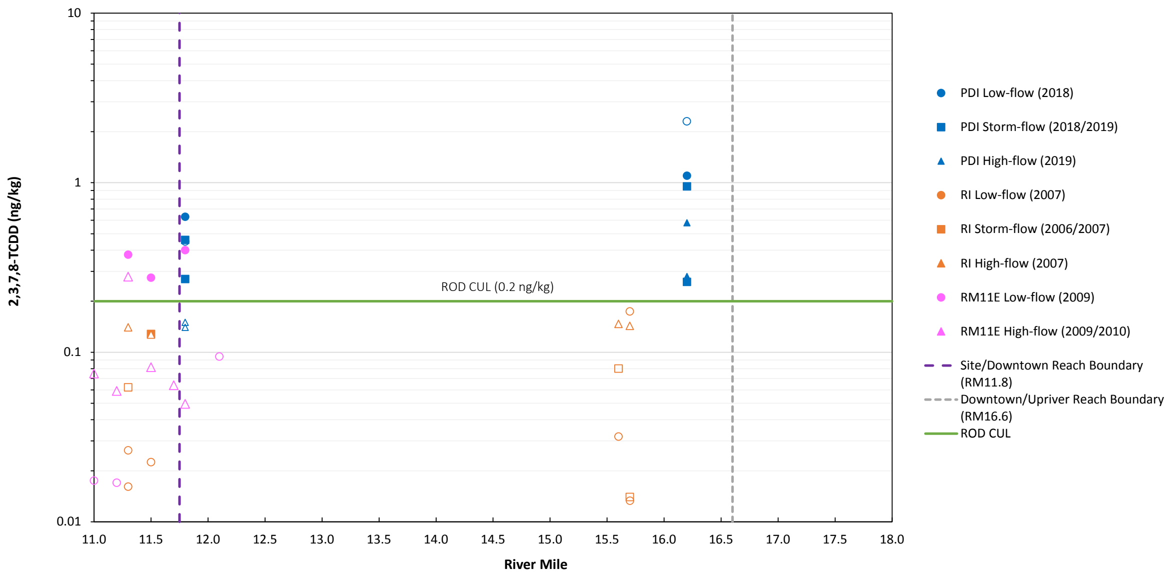


Figure 11c. Comparison of 2006/2007 RI, 2009/2010 RM11E, and 2018/2019 Sediment Trap Results – DDx

Notes:

1. Non-detect samples are shown as open symbols at the method detection limit.



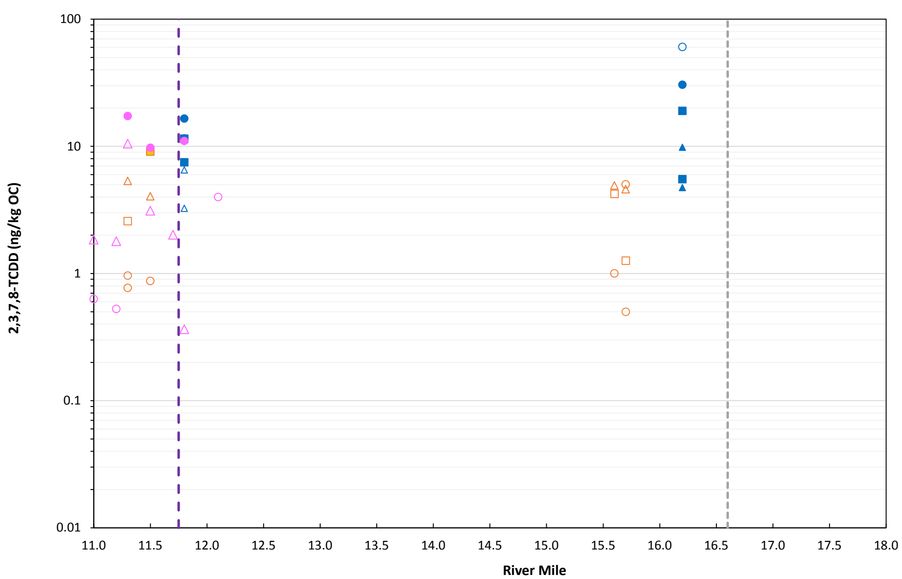
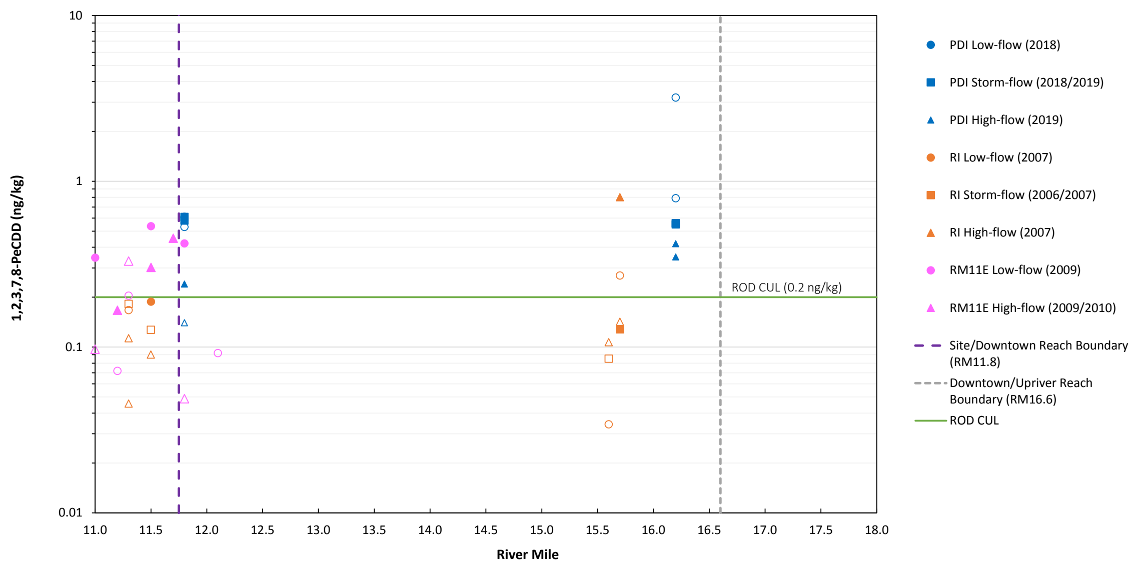


Figure 11d. Comparison of 2006/2007 RI, 2009/2010 RM11E, and 2018/2019 Sediment Trap Results – 2,3,7,8-TCDD

Notes:

1. Results below detection limits are shown as open symbols at the method detection limit.



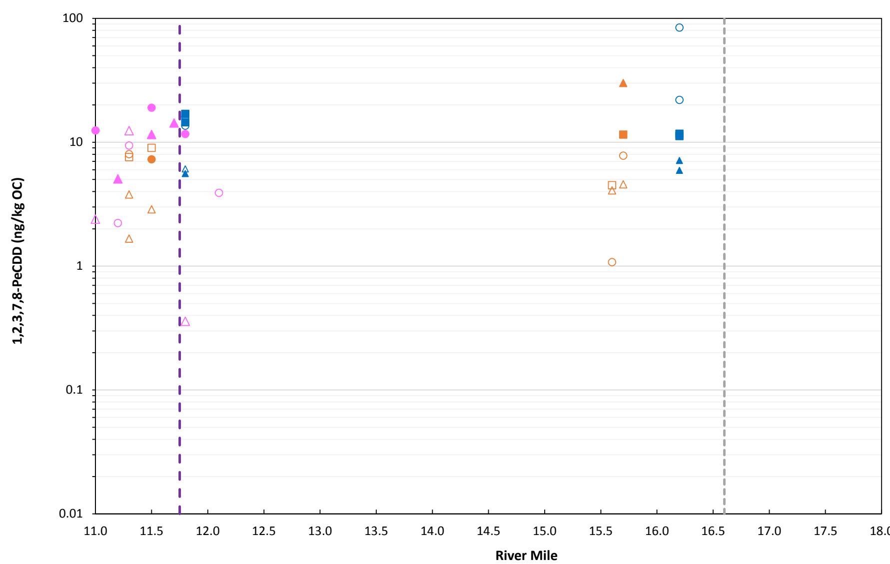
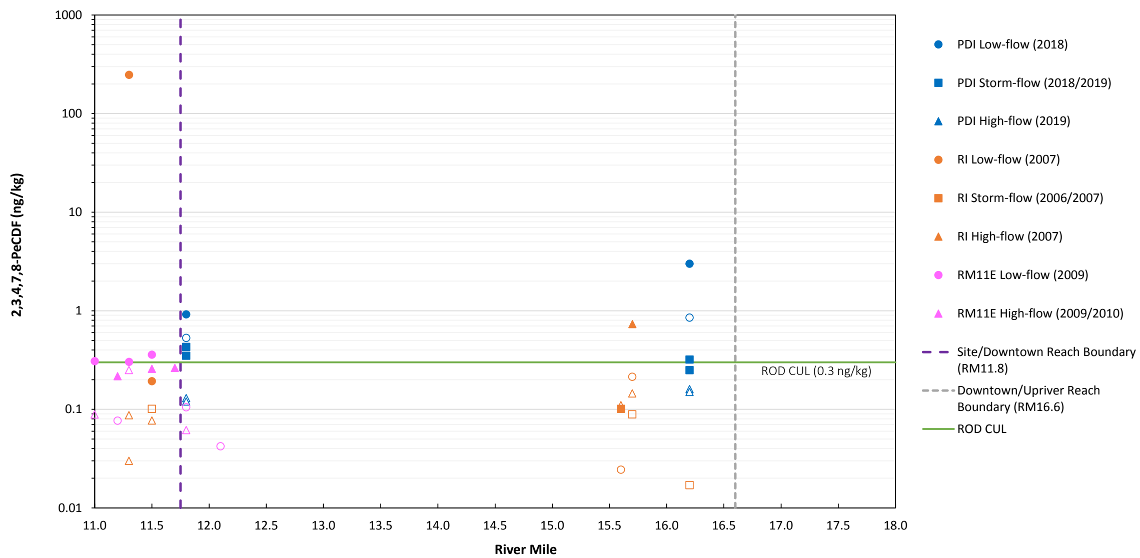


Figure 11e. Comparison of 2006/2007 RI, 2009/2010 RM11E, and 2018/2019 Sediment Trap Results – 1,2,3,7,8-PeCDD

General Notes:
1. Results below detection limits are shown as open symbols at the method detection limit.



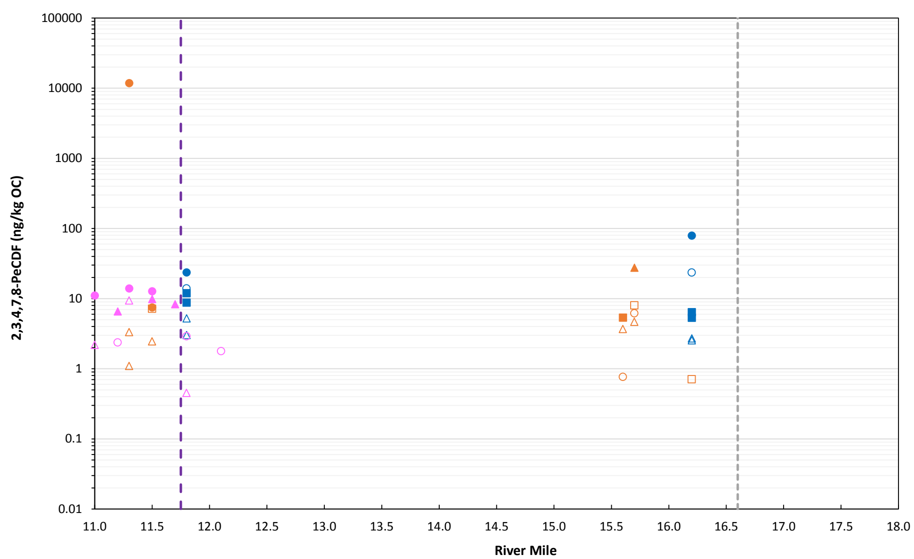


Figure 11f. Comparison of 2006/2007 RI, 2009/2010 RM11E, and 2018/2019 Sediment Trap Results – 2,3,4,7,8-PeCDF

General Notes:
1. Results below detection limits are shown as open symbols at the method detection limit.

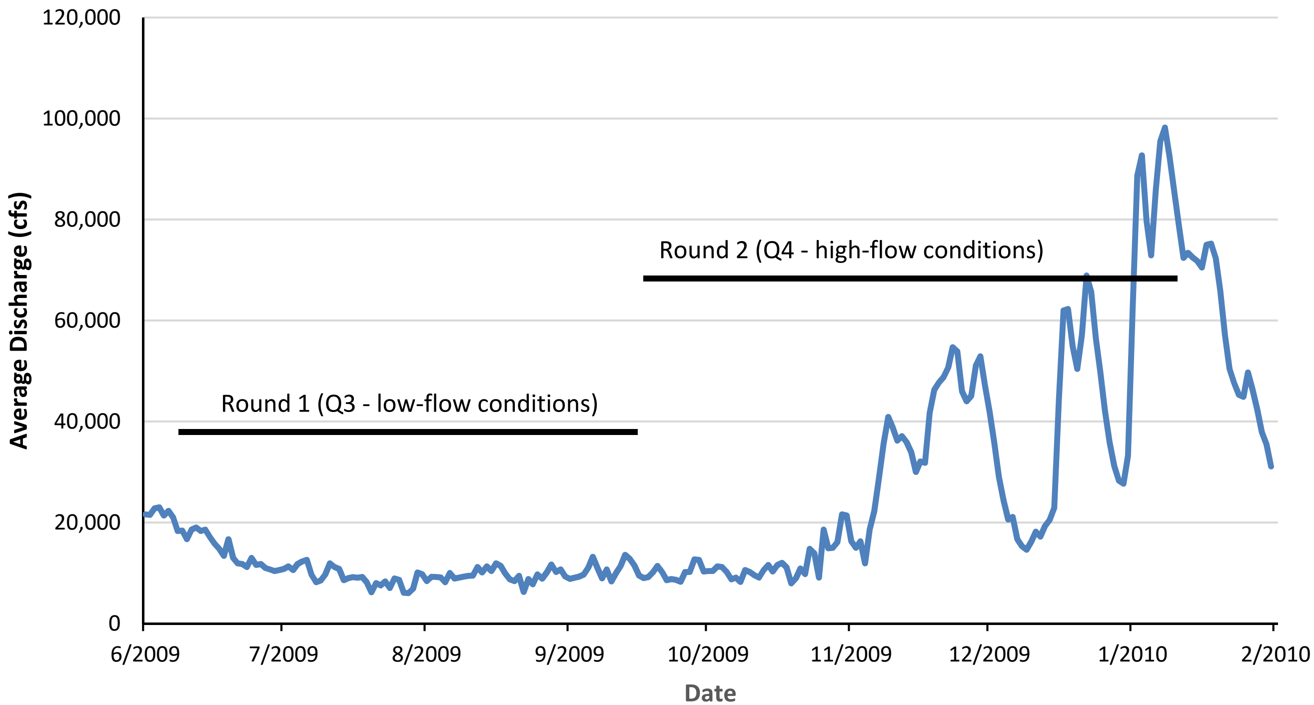


Figure 12. Willamette River 2009/2010 Hydrograph and Historical RM11E Sediment Trap Deployment Period

General Notes:

1. Flow measured at Morrison Street Bridge RM 12.7, USGS Gage 14211720, daily average calculated based on 15-minute intervals of measured flow.

2. RM11E Sediment traps were discussed specifically as low or storm-flow deployments in GSI (2010), but are described here based on similar conditions to PDI events.

cfs = cubic feet per second

EXHIBIT A

ProUCL Results for Sediment Trap Samples

	A	B	C	D	E	F	G	H	I	J	K	L
1	UCL Statistics for Data Sets with Non-Detects											
2												
3	User Selected Options											
4	Date/Time of Computation				ProUCL 5.15/30/2019 1:28:53 PM							
5	From File				3Rounds_ForProUCL_c.xls							
6	Full Precision				OFF							
7	Confidence Coefficient				95%							
8	Number of Bootstrap Operations				2000							
9												
10												
11	Sediment Trap_PCB											
12												
13	General Statistics											
14	Total Number of Observations					12	Number of Distinct Observations					12
15							Number of Missing Observations					0
16	Minimum					2.1	Mean					9.679
17	Maximum					41	Median					5.2
18	SD					11.75	Std. Error of Mean					3.392
19	Coefficient of Variation					1.214	Skewness					2.246
20												
21	Normal GOF Test											
22	Shapiro Wilk Test Statistic					0.644	Shapiro Wilk GOF Test					
23	5% Shapiro Wilk Critical Value					0.859	Data Not Normal at 5% Significance Level					
24	Lilliefors Test Statistic					0.361	Lilliefors GOF Test					
25	5% Lilliefors Critical Value					0.243	Data Not Normal at 5% Significance Level					
26	Data Not Normal at 5% Significance Level											
27												
28	Assuming Normal Distribution											
29	95% Normal UCL						95% UCLs (Adjusted for Skewness)					
30	95% Student's-t UCL					15.77	95% Adjusted-CLT UCL (Chen-1995)					17.61
31							95% Modified-t UCL (Johnson-1978)					16.14
32												
33	Gamma GOF Test											
34	A-D Test Statistic					0.987	Anderson-Darling Gamma GOF Test					
35	5% A-D Critical Value					0.751	Data Not Gamma Distributed at 5% Significance Level					
36	K-S Test Statistic					0.253	Kolmogorov-Smirnov Gamma GOF Test					
37	5% K-S Critical Value					0.251	Data Not Gamma Distributed at 5% Significance Level					
38	Data Not Gamma Distributed at 5% Significance Level											
39												
40	Gamma Statistics											
41	k hat (MLE)					1.273	k star (bias corrected MLE)					1.011
42	Theta hat (MLE)					7.601	Theta star (bias corrected MLE)					9.578
43	nu hat (MLE)					30.56	nu star (bias corrected)					24.25
44	MLE Mean (bias corrected)					9.679	MLE Sd (bias corrected)					9.628
45							Approximate Chi Square Value (0.05)					14.04
46	Adjusted Level of Significance					0.029	Adjusted Chi Square Value					12.87
47												
48	Assuming Gamma Distribution											
49	95% Approximate Gamma UCL (use when n>=50))					16.72	95% Adjusted Gamma UCL (use when n<50)					18.24
50												
51	Lognormal GOF Test											

	A–E	F	G–K	L
52	Shapiro Wilk Test Statistic	0.9	**Shapiro Wilk Lognormal GOF Test**	
53	5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level	
54	Lilliefors Test Statistic	0.178	**Lilliefors Lognormal GOF Test**	
55	5% Lilliefors Critical Value	0.243	Data appear Lognormal at 5% Significance Level	
56	**Data appear Lognormal at 5% Significance Level**			
57				
58	**Lognormal Statistics**			
59	Minimum of Logged Data	0.742	Mean of logged Data	1.828
60	Maximum of Logged Data	3.714	SD of logged Data	0.887
61				
62	**Assuming Lognormal Distribution**			
63	95% H-UCL	19.09	90% Chebyshev (MVUE) UCL	16.05
64	95% Chebyshev (MVUE) UCL	19.31	97.5% Chebyshev (MVUE) UCL	23.84
65	99% Chebyshev (MVUE) UCL	32.74		
66				
67	**Nonparametric Distribution Free UCL Statistics**			
68	**Data appear to follow a Discernible Distribution at 5% Significance Level**			
69				
70	**Nonparametric Distribution Free UCLs**			
71	95% CLT UCL	15.26	95% Jackknife UCL	15.77
72	95% Standard Bootstrap UCL	15.13	95% Bootstrap-t UCL	36.7
73	95% Hall's Bootstrap UCL	46.31	95% Percentile Bootstrap UCL	15.79
74	95% BCA Bootstrap UCL	17.83		
75	90% Chebyshev(Mean, Sd) UCL	19.86	95% Chebyshev(Mean, Sd) UCL	24.46
76	97.5% Chebyshev(Mean, Sd) UCL	30.86	99% Chebyshev(Mean, Sd) UCL	43.43
77				
78	**Suggested UCL to Use**			
79	95% H-UCL	19.09		
80				
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
82	Recommendations are based upon data size, data distribution, and skewness.			
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
85				
86	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**			
87	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**			
88	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**			
89	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**			
90				
91				
92	**Sediment Trap_DDx**			
93				
94	**General Statistics**			
95	Total Number of Observations	12	Number of Distinct Observations	9
96			Number of Missing Observations	0
97	Minimum	1.7	Mean	2.892
98	Maximum	5.1	Median	2.55
99	SD	1.088	Std. Error of Mean	0.314
100	Coefficient of Variation	0.376	Skewness	0.988
101				
102	**Normal GOF Test**			

	A–E	F	G–K	L
103	Shapiro Wilk Test Statistic	0.893	**Shapiro Wilk GOF Test**	
104	5% Shapiro Wilk Critical Value	0.859	Data appear Normal at 5% Significance Level	
105	Lilliefors Test Statistic	0.174	**Lilliefors GOF Test**	
106	5% Lilliefors Critical Value	0.243	Data appear Normal at 5% Significance Level	
107	**Data appear Normal at 5% Significance Level**			
108				
109	**Assuming Normal Distribution**			
110	**95% Normal UCL**		**95% UCLs (Adjusted for Skewness)**	
111	95% Student's-t UCL	3.456	95% Adjusted-CLT UCL (Chen-1995)	3.504
112			95% Modified-t UCL (Johnson-1978)	3.471
113				
114	**Gamma GOF Test**			
115	A-D Test Statistic	0.363	**Anderson-Darling Gamma GOF Test**	
116	5% A-D Critical Value	0.731	Detected data appear Gamma Distributed at 5% Significance Level	
117	K-S Test Statistic	0.16	**Kolmogorov-Smirnov Gamma GOF Test**	
118	5% K-S Critical Value	0.246	Detected data appear Gamma Distributed at 5% Significance Level	
119	**Detected data appear Gamma Distributed at 5% Significance Level**			
120				
121	**Gamma Statistics**			
122	k hat (MLE)	8.521	k star (bias corrected MLE)	6.446
123	Theta hat (MLE)	0.339	Theta star (bias corrected MLE)	0.449
124	nu hat (MLE)	204.5	nu star (bias corrected)	154.7
125	MLE Mean (bias corrected)	2.892	MLE Sd (bias corrected)	1.139
126			Approximate Chi Square Value (0.05)	127
127	Adjusted Level of Significance	0.029	Adjusted Chi Square Value	123.1
128				
129	**Assuming Gamma Distribution**			
130	95% Approximate Gamma UCL (use when n>=50))	3.524	95% Adjusted Gamma UCL (use when n<50)	3.634
131				
132	**Lognormal GOF Test**			
133	Shapiro Wilk Test Statistic	0.943	**Shapiro Wilk Lognormal GOF Test**	
134	5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level	
135	Lilliefors Test Statistic	0.143	**Lilliefors Lognormal GOF Test**	
136	5% Lilliefors Critical Value	0.243	Data appear Lognormal at 5% Significance Level	
137	**Data appear Lognormal at 5% Significance Level**			
138				
139	**Lognormal Statistics**			
140	Minimum of Logged Data	0.531	Mean of logged Data	1.002
141	Maximum of Logged Data	1.629	SD of logged Data	0.355
142				
143	**Assuming Lognormal Distribution**			
144	95% H-UCL	3.587	90% Chebyshev (MVUE) UCL	3.785
145	95% Chebyshev (MVUE) UCL	4.192	97.5% Chebyshev (MVUE) UCL	4.757
146	99% Chebyshev (MVUE) UCL	5.868		
147				
148	**Nonparametric Distribution Free UCL Statistics**			
149	**Data appear to follow a Discernible Distribution at 5% Significance Level**			
150				
151	**Nonparametric Distribution Free UCLs**			
152	95% CLT UCL	3.408	95% Jackknife UCL	3.456
153	95% Standard Bootstrap UCL	3.381	95% Bootstrap-t UCL	3.697

95% Hall's Bootstrap UCL	3.692	95% Percentile Bootstrap UCL	3.425
95% BCA Bootstrap UCL	3.458		
90% Chebyshev(Mean, Sd) UCL	3.834	95% Chebyshev(Mean, Sd) UCL	4.261
97.5% Chebyshev(Mean, Sd) UCL	4.854	99% Chebyshev(Mean, Sd) UCL	6.018
Suggested UCL to Use			
95% Student's-t UCL	3.456		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Sediment Trap_PAH			
General Statistics			
Total Number of Observations	12	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	43	Mean	148
Maximum	300	Median	140
SD	89.4	Std. Error of Mean	25.81
Coefficient of Variation	0.604	Skewness	0.367
Normal GOF Test			
Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.166	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.243	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	194.3	95% Adjusted-CLT UCL (Chen-1995)	193.4
		95% Modified-t UCL (Johnson-1978)	194.8
Gamma GOF Test			
A-D Test Statistic	0.38	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.151	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.248	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	2.657	k star (bias corrected MLE)	2.049
Theta hat (MLE)	55.7	Theta star (bias corrected MLE)	72.25
nu hat (MLE)	63.78	nu star (bias corrected)	49.16
MLE Mean (bias corrected)	148	MLE Sd (bias corrected)	103.4
		Approximate Chi Square Value (0.05)	34.07
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	32.16

Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	213.6	95% Adjusted Gamma UCL (use when n<50)	226.3
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.918	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.166	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.243	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.761	Mean of logged Data	4.797
Maximum of Logged Data	5.704	SD of logged Data	0.694
Assuming Lognormal Distribution			
95% H-UCL	254.8	90% Chebyshev (MVUE) UCL	244.7
95% Chebyshev (MVUE) UCL	287.3	97.5% Chebyshev (MVUE) UCL	346.5
99% Chebyshev (MVUE) UCL	462.8		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	190.5	95% Jackknife UCL	194.3
95% Standard Bootstrap UCL	188	95% Bootstrap-t UCL	198.1
95% Hall's Bootstrap UCL	191.7	95% Percentile Bootstrap UCL	188.8
95% BCA Bootstrap UCL	194.1		
90% Chebyshev(Mean, Sd) UCL	225.4	95% Chebyshev(Mean, Sd) UCL	260.5
97.5% Chebyshev(Mean, Sd) UCL	309.2	99% Chebyshev(Mean, Sd) UCL	404.8
Suggested UCL to Use			
95% Student's-t UCL	194.3		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Sediment Trap_TCDD			
General Statistics			
Total Number of Observations	12	Number of Distinct Observations	12
Number of Detects	8	Number of Non-Detects	4
Number of Distinct Detects	8	Number of Distinct Non-Detects	4
Minimum Detect	2.6000E-4	Minimum Non-Detect	1.4000E-4
Maximum Detect	0.0011	Maximum Non-Detect	0.0023
Variance Detects	1.0160E-7	Percent Non-Detects	33.33%
Mean Detects	5.6625E-4	SD Detects	3.1874E-4
Median Detects	5.2000E-4	CV Detects	0.563
Skewness Detects	0.761	Kurtosis Detects	-0.708
Mean of Logged Detects	-7.616	SD of Logged Detects	0.568

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.88	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.818	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.19	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.283	Detected Data appear Normal at 5% Significance Level	

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	4.5709E-4	KM Standard Error of Mean	1.0071E-4
KM SD	3.1172E-4	95% KM (BCA) UCL	6.1600E-4
95% KM (t) UCL	6.3795E-4	95% KM (Percentile Bootstrap) UCL	6.1500E-4
95% KM (z) UCL	6.2274E-4	95% KM Bootstrap t UCL	7.0305E-4
90% KM Chebyshev UCL	7.5921E-4	95% KM Chebyshev UCL	8.9606E-4
97.5% KM Chebyshev UCL	0.00109	99% KM Chebyshev UCL	0.00146

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.395	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.719	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.225	**Kolmogorov-Smirnov GOF**	
5% K-S Critical Value	0.296	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	3.733	k star (bias corrected MLE)	2.417
Theta hat (MLE)	1.5167E-4	Theta star (bias corrected MLE)	2.3430E-4
nu hat (MLE)	59.74	nu star (bias corrected)	38.67
Mean (detects)	5.6625E-4		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	2.6000E-4	Mean	0.00371
Maximum	0.01	Median	7.9000E-4
SD	0.00465	CV	1.254
k hat (MLE)	0.607	k star (bias corrected MLE)	0.511
Theta hat (MLE)	0.00611	Theta star (bias corrected MLE)	0.00726
nu hat (MLE)	14.57	nu star (bias corrected)	12.26
Adjusted Level of Significance (β)	0.029		
Approximate Chi Square Value (12.26, α)	5.399	Adjusted Chi Square Value (12.26, β)	4.722
95% Gamma Approximate UCL (use when n>=50)	0.00843	95% Gamma Adjusted UCL (use when n<50)	0.00963

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	4.5709E-4	SD (KM)	3.1172E-4
Variance (KM)	9.7170E-8	SE of Mean (KM)	1.0071E-4
k hat (KM)	2.15	k star (KM)	1.668
nu hat (KM)	51.6	nu star (KM)	40.04
theta hat (KM)	2.1258E-4	theta star (KM)	2.7400E-4

80% gamma percentile (KM)	6.9888E-4	90% gamma percentile (KM)	9.2825E-4
95% gamma percentile (KM)	0.00115	99% gamma percentile (KM)	0.00165

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (40.04, α)	26.54	Adjusted Chi Square Value (40.04, β)	24.87
95% Gamma Approximate KM-UCL (use when n>=50)	6.8956E-4	95% Gamma Adjusted KM-UCL (use when n<50)	7.3578E-4

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.9	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.215	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.283	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	4.4666E-4	Mean in Log Scale	-7.936
SD in Original Scale	3.1466E-4	SD in Log Scale	0.702
95% t UCL (assumes normality of ROS data)	6.0979E-4	95% Percentile Bootstrap UCL	5.9032E-4
95% BCA Bootstrap UCL	6.2509E-4	95% Bootstrap t UCL	6.8973E-4
95% H-UCL (Log ROS)	7.6342E-4		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-7.924	KM Geo Mean	3.6213E-4
KM SD (logged)	0.69	95% Critical H Value (KM-Log)	2.399
KM Standard Error of Mean (logged)	0.225	95% H-UCL (KM -Log)	7.5647E-4
KM SD (logged)	0.69	95% Critical H Value (KM-Log)	2.399
KM Standard Error of Mean (logged)	0.225		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	5.0417E-4	Mean in Log Scale	-7.93
SD in Original Scale	3.8254E-4	SD in Log Scale	0.942
95% t UCL (Assumes normality)	7.0249E-4	95% H-Stat UCL	0.00124

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	6.3795E-4		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Sediment Trap_PeCDD

General Statistics

Total Number of Observations	12	Number of Distinct Observations	11
Number of Detects	7	Number of Non-Detects	5

	A–E	F	G–K	L
358	Number of Distinct Detects	7	Number of Distinct Non-Detects	5
359	Minimum Detect	2.4000E-4	Minimum Non-Detect	1.4000E-4
360	Maximum Detect	6.1000E-4	Maximum Non-Detect	0.0032
361	Variance Detects	1.9324E-8	Percent Non-Detects	41.67%
362	Mean Detects	4.7286E-4	SD Detects	1.3901E-4
363	Median Detects	5.5000E-4	CV Detects	0.294
364	Skewness Detects	-0.842	Kurtosis Detects	-0.708
365	Mean of Logged Detects	-7.702	SD of Logged Detects	0.344
366				
367	**Normal GOF Test on Detects Only**			
368	Shapiro Wilk Test Statistic	0.883	**Shapiro Wilk GOF Test**	
369	5% Shapiro Wilk Critical Value	0.803	Detected Data appear Normal at 5% Significance Level	
370	Lilliefors Test Statistic	0.282	**Lilliefors GOF Test**	
371	5% Lilliefors Critical Value	0.304	Detected Data appear Normal at 5% Significance Level	
372	**Detected Data appear Normal at 5% Significance Level**			
373				
374	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**			
375	KM Mean	4.1284E-4	KM Standard Error of Mean	6.0551E-5
376	KM SD	1.6375E-4	95% KM (BCA) UCL	5.0778E-4
377	95% KM (t) UCL	5.2159E-4	95% KM (Percentile Bootstrap) UCL	5.0485E-4
378	95% KM (z) UCL	5.1244E-4	95% KM Bootstrap t UCL	5.0921E-4
379	90% KM Chebyshev UCL	5.9450E-4	95% KM Chebyshev UCL	6.7678E-4
380	97.5% KM Chebyshev UCL	7.9098E-4	99% KM Chebyshev UCL	0.00102
381				
382	**Gamma GOF Tests on Detected Observations Only**			
383	A-D Test Statistic	0.533	**Anderson-Darling GOF Test**	
384	5% A-D Critical Value	0.708	Detected data appear Gamma Distributed at 5% Significance Level	
385	K-S Test Statistic	0.303	**Kolmogorov-Smirnov GOF**	
386	5% K-S Critical Value	0.312	Detected data appear Gamma Distributed at 5% Significance Level	
387	**Detected data appear Gamma Distributed at 5% Significance Level**			
388				
389	**Gamma Statistics on Detected Data Only**			
390	k hat (MLE)	11.16	k star (bias corrected MLE)	6.471
391	Theta hat (MLE)	4.2382E-5	Theta star (bias corrected MLE)	7.3076E-5
392	nu hat (MLE)	156.2	nu star (bias corrected)	90.59
393	Mean (detects)	4.7286E-4		
394				
395	**Gamma ROS Statistics using Imputed Non-Detects**			
396	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
397	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)			
398	For such situations, GROS method may yield incorrect values of UCLs and BTVs			
399	This is especially true when the sample size is small.			
400	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			
401	Minimum	2.4000E-4	Mean	0.00444
402	Maximum	0.01	Median	5.9500E-4
403	SD	0.00491	CV	1.105
404	k hat (MLE)	0.618	k star (bias corrected MLE)	0.519
405	Theta hat (MLE)	0.00719	Theta star (bias corrected MLE)	0.00856
406	nu hat (MLE)	14.84	nu star (bias corrected)	12.46
407	Adjusted Level of Significance (β)	0.029		
408	Approximate Chi Square Value (12.46, α)	5.531	Adjusted Chi Square Value (12.46, β)	4.845

	A–E	F	G–K	L
409	95% Gamma Approximate UCL (use when n>=50)	0.01	95% Gamma Adjusted UCL (use when n<50)	0.0114
410				
411	**Estimates of Gamma Parameters using KM Estimates**			
412	Mean (KM)	4.1284E-4	SD (KM)	1.6375E-4
413	Variance (KM)	2.6815E-8	SE of Mean (KM)	6.0551E-5
414	k hat (KM)	6.356	k star (KM)	4.823
415	nu hat (KM)	152.5	nu star (KM)	115.7
416	theta hat (KM)	6.4953E-5	theta star (KM)	8.5606E-5
417	80% gamma percentile (KM)	5.5719E-4	90% gamma percentile (KM)	6.6459E-4
418	95% gamma percentile (KM)	7.6262E-4	99% gamma percentile (KM)	9.7013E-4
419				
420	**Gamma Kaplan-Meier (KM) Statistics**			
421	Approximate Chi Square Value (115.74, α)	91.9	Adjusted Chi Square Value (115.74, β)	88.67
422	95% Gamma Approximate KM-UCL (use when n>=50)	5.1993E-4	95% Gamma Adjusted KM-UCL (use when n<50)	5.3891E-4
423				
424	**Lognormal GOF Test on Detected Observations Only**			
425	Shapiro Wilk Test Statistic	0.848	**Shapiro Wilk GOF Test**	
426	5% Shapiro Wilk Critical Value	0.803	Detected Data appear Lognormal at 5% Significance Level	
427	Lilliefors Test Statistic	0.288	**Lilliefors GOF Test**	
428	5% Lilliefors Critical Value	0.304	Detected Data appear Lognormal at 5% Significance Level	
429	**Detected Data appear Lognormal at 5% Significance Level**			
430				
431	**Lognormal ROS Statistics Using Imputed Non-Detects**			
432	Mean in Original Scale	4.1929E-4	Mean in Log Scale	-7.824
433	SD in Original Scale	1.2979E-4	SD in Log Scale	0.328
434	95% t UCL (assumes normality of ROS data)	4.8658E-4	95% Percentile Bootstrap UCL	4.7627E-4
435	95% BCA Bootstrap UCL	4.7949E-4	95% Bootstrap t UCL	4.9063E-4
436	95% H-UCL (Log ROS)	5.1199E-4		
437				
438	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**			
439	KM Mean (logged)	-7.898	KM Geo Mean	3.7158E-4
440	KM SD (logged)	0.497	95% Critical H Value (KM-Log)	2.137
441	KM Standard Error of Mean (logged)	0.188	95% H-UCL (KM -Log)	5.7881E-4
442	KM SD (logged)	0.497	95% Critical H Value (KM-Log)	2.137
443	KM Standard Error of Mean (logged)	0.188		
444				
445	**DL/2 Statistics**			
446	**DL/2 Normal**		**DL/2 Log-Transformed**	
447	Mean in Original Scale	4.9542E-4	Mean in Log Scale	-7.841
448	SD in Original Scale	3.8376E-4	SD in Log Scale	0.739
449	95% t UCL (Assumes normality)	6.9437E-4	95% H-Stat UCL	8.9739E-4
450	**DL/2 is not a recommended method, provided for comparisons and historical reasons**			
451				
452	**Nonparametric Distribution Free UCL Statistics**			
453	**Detected Data appear Normal Distributed at 5% Significance Level**			
454				
455	**Suggested UCL to Use**			
456	95% KM (t) UCL	5.2159E-4		
457				
458	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
459	Recommendations are based upon data size, data distribution, and skewness.			

	A–E	F	G–K	L
460	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
461	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
462				
463	**Sediment Trap_PeCDF**			
464				
465	**General Statistics**			
466	Total Number of Observations	12	Number of Distinct Observations	12
467	Number of Detects	5	Number of Non-Detects	7
468	Number of Distinct Detects	5	Number of Distinct Non-Detects	7
469	Minimum Detect	2.5000E-4	Minimum Non-Detect	1.2000E-4
470	Maximum Detect	9.2000E-4	Maximum Non-Detect	0.003
471	Variance Detects	7.2030E-8	Percent Non-Detects	58.33%
472	Mean Detects	4.5400E-4	SD Detects	2.6838E-4
473	Median Detects	3.5000E-4	CV Detects	0.591
474	Skewness Detects	1.922	Kurtosis Detects	3.884
475	Mean of Logged Detects	-7.808	SD of Logged Detects	0.497
476				
477	**Normal GOF Test on Detects Only**			
478	Shapiro Wilk Test Statistic	0.773	**Shapiro Wilk GOF Test**	
479	5% Shapiro Wilk Critical Value	0.762	Detected Data appear Normal at 5% Significance Level	
480	Lilliefors Test Statistic	0.336	**Lilliefors GOF Test**	
481	5% Lilliefors Critical Value	0.343	Detected Data appear Normal at 5% Significance Level	
482	**Detected Data appear Normal at 5% Significance Level**			
483				
484	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**			
485	KM Mean	2.9159E-4	KM Standard Error of Mean	7.9271E-5
486	KM SD	2.2833E-4	95% KM (BCA) UCL	4.3875E-4
487	95% KM (t) UCL	4.3395E-4	95% KM (Percentile Bootstrap) UCL	4.2857E-4
488	95% KM (z) UCL	4.2198E-4	95% KM Bootstrap t UCL	4.4814E-4
489	90% KM Chebyshev UCL	5.2940E-4	95% KM Chebyshev UCL	6.3712E-4
490	97.5% KM Chebyshev UCL	7.8664E-4	99% KM Chebyshev UCL	0.00108
491				
492	**Gamma GOF Tests on Detected Observations Only**			
493	A-D Test Statistic	0.493	**Anderson-Darling GOF Test**	
494	5% A-D Critical Value	0.681	Detected data appear Gamma Distributed at 5% Significance Level	
495	K-S Test Statistic	0.284	**Kolmogorov-Smirnov GOF**	
496	5% K-S Critical Value	0.358	Detected data appear Gamma Distributed at 5% Significance Level	
497	**Detected data appear Gamma Distributed at 5% Significance Level**			
498				
499	**Gamma Statistics on Detected Data Only**			
500	k hat (MLE)	4.668	k star (bias corrected MLE)	2
501	Theta hat (MLE)	9.7260E-5	Theta star (bias corrected MLE)	2.2695E-4
502	nu hat (MLE)	46.68	nu star (bias corrected)	20
503	Mean (detects)	4.5400E-4		
504				
505	**Gamma ROS Statistics using Imputed Non-Detects**			
506	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
507	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)			
508	For such situations, GROS method may yield incorrect values of UCLs and BTVs			
509	This is especially true when the sample size is small.			
510	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			

	A	B	C	D	E	F	G	H	I	J	K	L
511					Minimum	2.5000E-4					Mean	0.00602
512					Maximum	0.01					Median	0.01
513					SD	0.00492					CV	0.817
514					k hat (MLE)	0.727					k star (bias corrected MLE)	0.6
515					Theta hat (MLE)	0.00829					Theta star (bias corrected MLE)	0.01
516					nu hat (MLE)	17.44					nu star (bias corrected)	14.41
517					Adjusted Level of Significance (β)	0.029						
518					Approximate Chi Square Value (14.41, α)	6.853					Adjusted Chi Square Value (14.41, β)	6.075
519					95% Gamma Approximate UCL (use when n>=50)	0.0127					95% Gamma Adjusted UCL (use when n<50)	0.0143
520												
521	**Estimates of Gamma Parameters using KM Estimates**											
522					Mean (KM)	2.9159E-4					SD (KM)	2.2833E-4
523					Variance (KM)	5.2136E-8					SE of Mean (KM)	7.9271E-5
524					k hat (KM)	1.631					k star (KM)	1.279
525					nu hat (KM)	39.14					nu star (KM)	30.69
526					theta hat (KM)	1.7880E-4					theta star (KM)	2.2804E-4
527					80% gamma percentile (KM)	4.5881E-4					90% gamma percentile (KM)	6.3188E-4
528					95% gamma percentile (KM)	8.0179E-4					99% gamma percentile (KM)	0.00119
529												
530	**Gamma Kaplan-Meier (KM) Statistics**											
531					Approximate Chi Square Value (30.69, α)	19.03					Adjusted Chi Square Value (30.69, β)	17.65
532					95% Gamma Approximate KM-UCL (use when n>=50)	4.7011E-4					95% Gamma Adjusted KM-UCL (use when n<50)	5.0712E-4
533												
534	**Lognormal GOF Test on Detected Observations Only**											
535					Shapiro Wilk Test Statistic	0.891	**Shapiro Wilk GOF Test**					
536					5% Shapiro Wilk Critical Value	0.762	Detected Data appear Lognormal at 5% Significance Level					
537					Lilliefors Test Statistic	0.255	**Lilliefors GOF Test**					
538					5% Lilliefors Critical Value	0.343	Detected Data appear Lognormal at 5% Significance Level					
539	**Detected Data appear Lognormal at 5% Significance Level**											
540												
541	**Lognormal ROS Statistics Using Imputed Non-Detects**											
542					Mean in Original Scale	2.8323E-4					Mean in Log Scale	-8.369
543					SD in Original Scale	2.2398E-4					SD in Log Scale	0.617
544					95% t UCL (assumes normality of ROS data)	3.9934E-4					95% Percentile Bootstrap UCL	3.9590E-4
545					95% BCA Bootstrap UCL	4.4447E-4					95% Bootstrap t UCL	5.0857E-4
546					95% H-UCL (Log ROS)	4.2998E-4						
547												
548	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
549					KM Mean (logged)	-8.381					KM Geo Mean	2.2911E-4
550					KM SD (logged)	0.667					95% Critical H Value (KM-Log)	2.365
551					KM Standard Error of Mean (logged)	0.24					95% H-UCL (KM -Log)	4.6046E-4
552					KM SD (logged)	0.667					95% Critical H Value (KM-Log)	2.365
553					KM Standard Error of Mean (logged)	0.24						
554												
555	**DL/2 Statistics**											
556	**DL/2 Normal**						**DL/2 Log-Transformed**					
557					Mean in Original Scale	3.9500E-4					Mean in Log Scale	-8.32
558					SD in Original Scale	4.2288E-4					SD in Log Scale	1.055
559					95% t UCL (Assumes normality)	6.1423E-4					95% H-Stat UCL	0.00111
560	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
561												

Nonparametric Distribution Free UCL Statistics			
Detected Data appear Normal Distributed at 5% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	4.3395E-4		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Sediment Trap_TEQs			
General Statistics			
Total Number of Observations	12	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	9.8000E-4	Mean	0.00362
Maximum	0.011	Median	0.0032
SD	0.00262	Std. Error of Mean	7.5723E-4
Coefficient of Variation	0.724	Skewness	2.201
Normal GOF Test			
Shapiro Wilk Test Statistic	0.77	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.276	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.243	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	0.00498	95% Adjusted-CLT UCL (Chen-1995)	0.00538
		95% Modified-t UCL (Johnson-1978)	0.00506
Gamma GOF Test			
A-D Test Statistic	0.398	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.19	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.248	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	2.736	k star (bias corrected MLE)	2.108
Theta hat (MLE)	0.00132	Theta star (bias corrected MLE)	0.00172
nu hat (MLE)	65.67	nu star (bias corrected)	50.59
MLE Mean (bias corrected)	0.00362	MLE Sd (bias corrected)	0.0025
		Approximate Chi Square Value (0.05)	35.26
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	33.31
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	0.0052	95% Adjusted Gamma UCL (use when n<50)	0.0055

Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.957	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.17	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.243	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-6.928	Mean of logged Data	-5.814
Maximum of Logged Data	-4.51	SD of logged Data	0.645
Assuming Lognormal Distribution			
95% H-UCL	0.00578	90% Chebyshev (MVUE) UCL	0.00569
95% Chebyshev (MVUE) UCL	0.00663	97.5% Chebyshev (MVUE) UCL	0.00794
99% Chebyshev (MVUE) UCL	0.0105		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.00487	95% Jackknife UCL	0.00498
95% Standard Bootstrap UCL	0.00481	95% Bootstrap-t UCL	0.00598
95% Hall's Bootstrap UCL	0.011	95% Percentile Bootstrap UCL	0.00502
95% BCA Bootstrap UCL	0.00539		
90% Chebyshev(Mean, Sd) UCL	0.0059	95% Chebyshev(Mean, Sd) UCL	0.00692
97.5% Chebyshev(Mean, Sd) UCL	0.00835	99% Chebyshev(Mean, Sd) UCL	0.0112
Suggested UCL to Use			
95% Adjusted Gamma UCL	0.0055		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness.			
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			
Sediment Trap_Fines			
General Statistics			
Total Number of Observations	12	Number of Distinct Observations	12
		Number of Missing Observations	0
Minimum	31.8	Mean	73.07
Maximum	93.7	Median	86.1
SD	23.72	Std. Error of Mean	6.848
Coefficient of Variation	0.325	Skewness	-0.84
Normal GOF Test			
Shapiro Wilk Test Statistic	0.771	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.307	**Lilliefors GOF Test**	

	A B C D E	F	G H I J K	L
664	5% Lilliefors Critical Value	0.243	Data Not Normal at 5% Significance Level	
665	**Data Not Normal at 5% Significance Level**			
666				
667	**Assuming Normal Distribution**			
668	**95% Normal UCL**		**95% UCLs (Adjusted for Skewness)**	
669	95% Student's-t UCL	85.36	95% Adjusted-CLT UCL (Chen-1995)	82.56
670			95% Modified-t UCL (Johnson-1978)	85.09
671				
672	**Gamma GOF Test**			
673	A-D Test Statistic	1.437	**Anderson-Darling Gamma GOF Test**	
674	5% A-D Critical Value	0.731	Data Not Gamma Distributed at 5% Significance Level	
675	K-S Test Statistic	0.336	**Kolmogorov-Smirnov Gamma GOF Test**	
676	5% K-S Critical Value	0.246	Data Not Gamma Distributed at 5% Significance Level	
677	**Data Not Gamma Distributed at 5% Significance Level**			
678				
679	**Gamma Statistics**			
680	k hat (MLE)	8.207	k star (bias corrected MLE)	6.211
681	Theta hat (MLE)	8.903	Theta star (bias corrected MLE)	11.76
682	nu hat (MLE)	197	nu star (bias corrected)	149.1
683	MLE Mean (bias corrected)	73.07	MLE Sd (bias corrected)	29.32
684			Approximate Chi Square Value (0.05)	121.8
685	Adjusted Level of Significance	0.029	Adjusted Chi Square Value	118.1
686				
687	**Assuming Gamma Distribution**			
688	95% Approximate Gamma UCL (use when n>=50))	89.39	95% Adjusted Gamma UCL (use when n<50)	92.23
689				
690	**Lognormal GOF Test**			
691	Shapiro Wilk Test Statistic	0.759	**Shapiro Wilk Lognormal GOF Test**	
692	5% Shapiro Wilk Critical Value	0.859	Data Not Lognormal at 5% Significance Level	
693	Lilliefors Test Statistic	0.337	**Lilliefors Lognormal GOF Test**	
694	5% Lilliefors Critical Value	0.243	Data Not Lognormal at 5% Significance Level	
695	**Data Not Lognormal at 5% Significance Level**			
696				
697	**Lognormal Statistics**			
698	Minimum of Logged Data	3.459	Mean of logged Data	4.229
699	Maximum of Logged Data	4.54	SD of logged Data	0.392
700				
701	**Assuming Lognormal Distribution**			
702	95% H-UCL	94.08	90% Chebyshev (MVUE) UCL	99
703	95% Chebyshev (MVUE) UCL	110.5	97.5% Chebyshev (MVUE) UCL	126.4
704	99% Chebyshev (MVUE) UCL	157.7		
705				
706	**Nonparametric Distribution Free UCL Statistics**			
707	**Data do not follow a Discernible Distribution (0.05)**			
708				
709	**Nonparametric Distribution Free UCLs**			
710	95% CLT UCL	84.33	95% Jackknife UCL	85.36
711	95% Standard Bootstrap UCL	84.03	95% Bootstrap-t UCL	84.5
712	95% Hall's Bootstrap UCL	82.33	95% Percentile Bootstrap UCL	83.57
713	95% BCA Bootstrap UCL	82.52		
714	90% Chebyshev(Mean, Sd) UCL	93.61	95% Chebyshev(Mean, Sd) UCL	102.9

97.5% Chebyshev(Mean, Sd) UCL	115.8	99% Chebyshev(Mean, Sd) UCL	141.2

Suggested UCL to Use

95% Student's-t UCL	85.36	or 95% Modified-t UCL	85.09

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Sediment Trap_Total Orgnic Carbon

General Statistics

Total Number of Observations	12	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	23000	Mean	42333
Maximum	59000	Median	39500
SD	10201	Std. Error of Mean	2945
Coefficient of Variation	0.241	Skewness	0.192

Normal GOF Test

Shapiro Wilk Test Statistic	0.926	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.859	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.184	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.243	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	47622	95% Adjusted-CLT UCL (Chen-1995)	47351
		95% Modified-t UCL (Johnson-1978)	47649

Gamma GOF Test

A-D Test Statistic	0.441	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.732	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.195	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.245	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	17.9	k star (bias corrected MLE)	13.48
Theta hat (MLE)	2365	Theta star (bias corrected MLE)	3140
nu hat (MLE)	429.6	nu star (bias corrected)	323.5
MLE Mean (bias corrected)	42333	MLE Sd (bias corrected)	11530
		Approximate Chi Square Value (0.05)	282.9
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	277.1

Assuming Gamma Distribution

	A	B	C	D	E	F	G	H	I	J	K	L
766	95% Approximate Gamma UCL (use when n>=50))					48421	95% Adjusted Gamma UCL (use when n<50)					49435
767												
768	**Lognormal GOF Test**											
769	Shapiro Wilk Test Statistic					0.911	**Shapiro Wilk Lognormal GOF Test**					
770	5% Shapiro Wilk Critical Value					0.859	Data appear Lognormal at 5% Significance Level					
771	Lilliefors Test Statistic					0.216	**Lilliefors Lognormal GOF Test**					
772	5% Lilliefors Critical Value					0.243	Data appear Lognormal at 5% Significance Level					
773	**Data appear Lognormal at 5% Significance Level**											
774												
775	**Lognormal Statistics**											
776	Minimum of Logged Data					10.04	Mean of logged Data					10.63
777	Maximum of Logged Data					10.99	SD of logged Data					0.254
778												
779	**Assuming Lognormal Distribution**											
780	95% H-UCL					49097	90% Chebyshev (MVUE) UCL					51758
781	95% Chebyshev (MVUE) UCL					56003	97.5% Chebyshev (MVUE) UCL					61896
782	99% Chebyshev (MVUE) UCL					73470						
783												
784	**Nonparametric Distribution Free UCL Statistics**											
785	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
786												
787	**Nonparametric Distribution Free UCLs**											
788	95% CLT UCL					47177	95% Jackknife UCL					47622
789	95% Standard Bootstrap UCL					46809	95% Bootstrap-t UCL					48312
790	95% Hall's Bootstrap UCL					47874	95% Percentile Bootstrap UCL					47167
791	95% BCA Bootstrap UCL					46833						
792	90% Chebyshev(Mean, Sd) UCL					51168	95% Chebyshev(Mean, Sd) UCL					55169
793	97.5% Chebyshev(Mean, Sd) UCL					60723	99% Chebyshev(Mean, Sd) UCL					71634
794												
795	**Suggested UCL to Use**											
796	95% Student's-t UCL					47622						
797												
798	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
799	Recommendations are based upon data size, data distribution, and skewness.											
800	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
801	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
802												

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